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Master Thesis

The role of the discount rate in the cost-benefit analysis between theory and practice, a survey

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Authorship declaration

I hereby declare and confirm that this thesis is entirely the result of my own work except where otherwise indicated. I acknowledge the supervisions and guidance I have received from Professor Doctor Alessandra Arcuri. This thesis is not used as part of any other examination and has not yet been published.

Rome, the 10th of August 2011

Felice Simonelli
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1. Research question and scope of the work

1.1. Research question

In the current institutional and regulatory framework, Cost-Benefit Analysis (CBA)\(^1\) represents the most comprehensive decision method and evaluation tool for the assessment of any public policy intervention, investment project or regulation characterized by a significant economic, environmental or social impact\(^2\). Nonetheless, the theoretical debate on CBA still leaves open several questions and relevant methodological problems to which scholars often offer controversial solutions. Such a long-lasting academic discussion could somehow result in a disconnection between the elaborated findings of “the theoreticians” and the concrete needs of “the practitioners”. Undoubtedly, this risk should be avoided in the context of CBA. In fact, the workability of this instrument is one of its most significant features, in particular considering the limited set of data and information that analysts usually have at their disposal. Therefore, the attempt to concretely understand how and to which extent the economic and the Law and Economics (L&E) literature affects the choices of regulators and analysts on CBA, and thereby the regulatory decisions, could be a functional task.

The main spillover of this analysis could provide a view to better understand the role of CBA in the regulatory decision-making process. From a “normative” perspective, as an indisputable and unbiased method of decision, high accuracy and reliability should be required in CBAs; hence, for this role a rigorous application of the theoretical

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\(^1\) A list of all the acronyms used in the work is provided in Appendix D.

\(^2\) For USA see Executive Order 13563 (18/Jan/2011); for EU see Communication COM(2010)543 (08/Oct/2010).
insights may be strictly necessary. To the contrary from a more limited perspective (which can be termed “supportive”), as a helpful (but not conclusive) input for public decisions, CBA should favor high workability and flexibility; hence, for this role a simpler application of more practical rules may be sufficient.\footnote{For instance, as Posner explains, in a normative CBA (which Posner himself advocates) the use of a Kaldor-Hicks criterion must be carefully justified “because of its well know normative inadequacies”; on the contrary in a positive CBA that criterion can be used with more superficiality just accepting it as one of the possible alternative social value (Posner (2000), p.1154).}

1.1.1. A focus on the social discount rate

In order to comply with the limited length of this work, this broad task needs to be effectively narrowed, thus focusing on one of the several problems which affect the CBA methodology. From this perspective the Social Discount Rate (SDR) would be the most suitable candidate for a similar investigation.

The SDR has a significant effect on the assessment of the Net Present Value (NPV) of any project and therefore on the quantitative results of a CBA. It also involves ethical considerations for intergenerational regulatory impacts. Furthermore, as well as for many other variables involved in a CBA, at the present state of art, a consensus among economists about the most appropriate theoretical approach to be adopted for the determination of the SDR has not been reached yet. Nevertheless, this rate has been a topic of strong discussion in the last decades, hence presumably the main theoretical hints should have already affected the choices of regulators and analysts. Accordingly, a focus on the SDR could turn to be a good proxy to comprehend the potential effects of the theoretical debate on the accuracy, reliability and objectivity of the CBA and thereby on the regulatory production.
1.2. Method and scope of the work

The analysis described above is based on a survey of both the main literature on the SDR and the related empirical application. For this reason the work is divided into three main parts. The first part (chapter 2) aims at defining the CBA in the L&E world and at briefly delineating the institutionalization process for this analytical tool. The second part (chapter 3) focuses on the theoretical debate on the role of the SDR in the CBA, trying to offer an illustration of the main conclusions concerning the discounting techniques and the choice of the proper discount rate. The third part (chapter 4) includes an empirical survey of the use of the SDR in the CBA of policy-making, first pointing out the methods suggested by the United States (US) and European Union (EU) public authorities and then analyzing a selected sample of CBAs included in both American Regulatory Impact Analyses (RIAs) and European Impact Assessments (IAs), thus providing an overview never carried out before. Eventually, a conclusive section (chapter 5) recaps the main results of the work.
2. Cost-benefit analysis: a Law and Economics perspective

2.1. A possible definition from the literature

In the L&E literature, CBA has several meanings and uses. According to the definition provided by Sen\(^4\), CBA can be considered as any assessment that, regardless of the technique adopted, is rooted on the basic principle for which it is worth undertaking an action only when its benefits outweigh its costs. Therefore CBA requires the explicit evaluation of all the broad possible consequences of an activity as “foundational principle”, thus obtaining comparable figures (expressed in the same metric) and eventually computing the Net Benefits\(^5\) (NBs) of a project.

From another perspective, Richard Posner\(^6\) explains that the broader meaning of the CBA is the “normative” one, considering this analysis as a synonym of welfare economics and using this method as an accurate guidance for public policies. The narrower meaning, instead, refers to the generic application of a Kaldor-Hicks\(^7\) criterion to evaluate government projects, grants and regulations, “including statutes and common law doctrines and decisions”\(^8\). Posner offers also another axis of definition, referring the term CBA to three alternative uses\(^9\): “a method of pure evaluation”, thus carrying out an analysis without regard to the potential use of its outcomes in a decision; a preliminary “input for a decision” process, thus giving to the decision-maker the opportunity to refuse the results of the analysis on the basis of

\(^4\) Sen (2000).
\(^5\) NBs result after deducting total costs from total benefits.
\(^6\) Posner (2000).
\(^7\) For an accurate discussion on the Kaldor-Hicks efficiency criterion (or potential Pareto efficiency) see Kaldor (1939) and Hicks (1939) who provide two slightly different definitions of the concept.
\(^9\) Ibidem, p.1154.
wider political considerations; an “exclusive method of decision”, thus playing a role that corresponds to the broad “normative” meaning.

Lastly, Viscusi\textsuperscript{10} provides a more workable definition of CBA as “the most comprehensive form of regulatory analysis”\textsuperscript{11}, therefore pointing out the “supportive” perspective. The rationale is that resources are limited and should be allocated to the most efficient available alternative\textsuperscript{12}. It follows that the ultimate purpose of a CBA consists of measuring and weighting the total expected positive and negative effects of one or more proposals, in order to judge the potential attractiveness of any option and to select the most efficient one to be adopted. Practically, all the consequences of a regulation are expressed in terms of monetary costs and benefits, thus computing a quantitative net result. Regulatory options with positive NBs are desirable\textsuperscript{13}.

2.2. The actual role of cost-benefit analysis in the regulatory decision-making process

In the current regulatory framework, CBA is certainly the main and the broadest method\textsuperscript{14} used in the so-called RIA, which aims at systematically evaluating the overall impacts of existing or proposed norms in order to inform policy-makers. As shown by the application of this analytical tool in many country of the Organisation for Economic Co-operation and Development (OECD), a proper RIA program can “improve the effectiveness and efficiency of governments and can help address broader issues of

\textsuperscript{10}Viscusi, W.K. (1997).

\textsuperscript{11}Ibidem, p.180.

\textsuperscript{12}See also Arrow et al. (1996): “because society has limited resources to spend on regulation, benefit-cost analysis can help illuminate the trade-offs involved in making different kinds of social investments.”

\textsuperscript{13}This is the classical application of the so called “benefit-cost test”.

\textsuperscript{14}Several alternative methods are currently used in the RIA carried out by OECD members, but CBA is the only integrated approach capable to measure the overall impact of a regulation (Jacobs (2007)).
competitiveness and economic performance”, also ameliorating “the quality of political and administrative decision-making”\textsuperscript{15}.

From this perspective CBA represents one of the most significant cases where the economic and L&E theory has a direct impact on the legal and regulatory production, thus affecting and improving the main decisions of rule-makers in USA, in EU and in several other countries.

2.2.1. The institutionalization process in USA

It is not by chance that RIA and CBA were born in USA, considering that in the world largest economy the use of financial resources to assess regulatory options is likely to result in higher potential benefits than in smaller economies\textsuperscript{16}.

Actually the first modern application of the CBA can be found in the “River and Harbor Act” of 1902, where a specific evaluation of benefits and costs which affected commerce was required from engineers who realized rivers and harbor projects. In 1950 an inter-agency committee edited the so called "Green Book"\textsuperscript{17}, trying to codify for the first time general principles to be applied to CBA. This kind of analysis was considered as a practical way of evaluating the desirability of projects. Moreover, during the 60s economists started to give to the term “project” a broader meaning, raising the awareness that the CBA could have been applied also to any legislative change\textsuperscript{18}.

\textsuperscript{15} OECD (1997), p.7.
\textsuperscript{16} Morral (1997).
\textsuperscript{17} Inter-Agency River Basin Committee (1950) in Prest and Turvey (1965).
\textsuperscript{18} Prest and Turvey (1965).
The institutionalization of the RIA found its origin in the US, in the so-called “Quality of Life Review” program proposed by the Nixon Administration in 1971, but the lack of an economic evaluation of benefits and costs of regulations marked the failure of this program. In 1974, for the first time, the “Council on Wage and Price Stability”, which was entrusted by President Ford with the task of preparing inflation impact statement for new regulatory alternatives, proposed to employ CBA. President Carter in 1978 strengthened the RIA creating the “Regulatory Analysis Review Group” to review the most relevant regulations issued during the year. Afterwards, both the Reagan’s\(^\text{19}\) and the first Bush’s administrations focused on the so called “regulatory relief” in order to reduce the regulatory burden, introducing the “benefit-cost test” for new regulations and centralizing the assessment process in the Office of Information and Regulatory Affairs (OIRA)\(^\text{20}\). In 1993 President Clinton issued his Executive Order on “Regulatory Planning and Review”, improving the openness and the accountability of the RIA, accelerating the whole process, and limiting the review only to the regulations that had a significant impact on the economy\(^\text{21}\).

During the Bush (son) administration the centrality of CBA as main tool of analysis for RIAs was confirmed and the responsibilities of the OIRA were strengthened. Recently, President Obama, with the Executive Order 13563 (18/Jan/2011), slightly modified the principles at the basis of CBA, trying to include some insights from the Behavioral L&E\(^\text{22}\). This new trend has been prompted by the appointment of Cass R. Sunstein as

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\(^{19}\) Actually the expression RIA was institutionalized by President Regan in the Section 3 of the Executive Order 12291 (17/Feb/1981).

\(^{20}\) This office administrates the regulatory review program within the Office of Management and Budget.

\(^{21}\) Morrall (1997).

\(^{22}\) In the Section 4 of the Executive Order 13563 (18/Jan/2011) are embedded the main insights of the so called “libertarian paternalism” (see Sunstein and Thaler (2003)).
president of the OIRA, who promoted a “humanization” of CBA\textsuperscript{23} through a triple approach: first, paying attention on “how people really behave”; second, using CBA as a pragmatic tool to evaluate “the human consequences of regulation”; third, giving a “new emphasis on transparency”.

\textbf{2.2.2. The institutionalization process in EU}

The roots of the current European IA system are younger and can be found in the so-called Business Impact Assessment (BIA) proposed in 1986 by the UK presidency of the Council. This pilot project focused on assessing the impacts, which were expressed in terms of compliance costs, of a selected number of European regulations on businesses. BIAs led to poor results and were subject to several criticisms, mainly related to incompleteness and to an unclear institutional setting\textsuperscript{24}.

In July 2001 the European Commission (EC) issued a White Paper\textsuperscript{25} requiring the creation of a high level advisory group to draft “an action plan for better regulation”. As a result, in November 2001, the “Mandelkern Group on Better Regulation”\textsuperscript{26} published a final report giving relevant inputs to reform the European IA model\textsuperscript{27}. Moreover, in 2002 the Directorate General for Enterprise and Industry of the EC acknowledged the necessity to introduce a broader approach in order to improve the “better regulation” reform\textsuperscript{28}. The Commission explicitly recognized that “regulatory quality [results] as essential for economic growth, competitiveness and innovation in

\textsuperscript{23} Sunstein (2010), p.2.
\textsuperscript{24} Renda (2011).
\textsuperscript{25} Commission (2001).
\textsuperscript{26} Mandelkern Group (2001).
\textsuperscript{27} Renda (2011).
\textsuperscript{28} Enterprise Directorate (2002).
the internal market”\textsuperscript{29} and that, “considering that policy-makers are expected to act in
the interests of society as a whole, […] CBA should be the preferred option for
economic analysis of policy actions”\textsuperscript{30}.

This reforming process led to the Communication COM(2002)276, where the IA
process was officially introduced “as a tool to improve the quality and coherence of
the policy development process”\textsuperscript{31}. The Commission aimed at building an Integrated
Impact Assessment (IIA) system, “intended to integrate, reinforce, streamline and
replace all the existing separate impact assessment mechanisms for Commission
proposals”\textsuperscript{32}. Afterwards, in the Communication COM(2005)97 it was stressed that
“the Commission’s commitment to […] IIA was […] designed to allow policy-makers to
make choices on the basis of careful analysis of the potential economic, social and
environmental impacts of new legislation”\textsuperscript{33}. Furthermore, to control the quality of the
IIA, in 2007 the Commission created the Impact Assessment Board (IAB) with the main
task of examining and issuing opinions on all the Commission’s IAs.

Actually, the broad objective assigned to the IA system can be fully achieved only
applying the CBA method. Nevertheless, as Renda\textsuperscript{34} explains, the role of CBA in the EU
IA is less clear than in USA. In paragraph 7.3 of the of the 2009 “Impact Assessment
Guidelines” the EC states that “the aim of all interventions is of course to provide
benefits that exceed any possible negative impacts[,] in the terminology of [CBA] this

\textsuperscript{29} Ibidem, p.3.
\textsuperscript{30} Ibidem, p.16.
\textsuperscript{32} Ibidem, p.3.
\textsuperscript{34} Renda (2011).
means that you should select options that promise the greatest net benefits”\textsuperscript{35}. Nevertheless, the role of CBA is limited in paragraph 9.1 of the same document where it is acknowledged that “full cost-benefit analysis should be used when the most significant part of both costs and benefits can be quantified and monetized”\textsuperscript{36}.

To conclude, the recent Communication COM(2010)543 should have marked the shift “from better to smart regulation” aiming at improving “the [entire] policy cycle from when a piece of legislation is designed to when it is revised”\textsuperscript{37}. Confirming that the IA “is based on an analysis of benefits and costs”, that “impact assessments should quantify benefits and costs when possible”, and that “the Commission will continue efforts to improve in this area”, a new tool of the “smart regulation” is the evaluation of benefits and costs of existing legislations\textsuperscript{38}. Therefore, in the light of the last Communication, CBA in the EU seems to be consecrated with a new and more decisive role.

From this viewpoint, it is worthwhile to underline that while in the US RIAs are carried out on for secondary legislation issued by government agencies, in EU IAs apply to all the main initiatives included in the EU Commission “Legislative and Work Programme”, thus playing the wider role of informing “the legislator” rather than just “the regulator”.

\textsuperscript{35} EC (2009), p.31.
\textsuperscript{36} Ibidem, p.45.
\textsuperscript{38} Ibidem, p.6-7.
2.3. Summing-up

The L&E literature focuses on the role of CBA as a powerful tool to assess public policies and in particular legislative and regulatory options, either in a “normative” or in a more limited perspective (which can be termed “supportive”). Actually, the function of the CBA in the regulatory process has been institutionalized both in USA and in EU. Nonetheless, the academic debate on the CBA is still open. From a theoretical perspective, all the variables involved in a comprehensive CBA raise methodological issues that scholars in the course of time have tried to solve without reaching a consensus. In order to comply with the limited length of this thesis, the next chapters are exclusively focused on the choice and the adoption of an appropriate discount rate, one of the most controversial methodological problems which affects any CBA.

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39 Among the most controversial academic discussions, it is worthwhile to mention the significant difficulties faced in: monetizing all the positive and negative effects of a project, with particular concern for non-market goods (human life, natural resources and so on) and opportunity costs; measuring the variation of the utilities of the individuals involved; selecting and applying an efficiency criterion; selecting and applying a social welfare function in order to take into account the distributional effect of a policy; accounting for the time factor when the effects occur in different future moments; dealing with risk and uncertainty.
Chapter 3. The role of the discount rate in the cost-benefit analysis: a theoretical approach

3.1. The discount rate: why costs and benefits should be discounted?

In order to carry out a CBA of regulatory and legislative policies, analysts have to face the problem of comparing positive and negative effects which do not occur immediately, but over a long period of time, taking place in different future moments. The time period in correspondence to which benefits and costs accrue is extremely important because a given quantity of resources available in the future is considered to be less worth than the same amount available at present\(^{40}\).

This statement is based on the common evidence that individuals have “time preferences”, thus preferring to consume a given amount of resources now rather than in a future moment and, likewise, to receive a given income sooner rather than later. A similar behavior can be explained on the basis of two main considerations: first, people are uncertain about the future, therefore they take into account this kind of risk\(^{41}\) in their consumption choices\(^{42}\) (“utility discount factor”); second, relying on the economic growth assumption, people expect that society and individuals will be wealthier in the future, therefore they expect to gain less utility from future consumption\(^{43}\) (“utility growth factor”). Moreover, also private firms and governments

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\(^{40}\) For further discussions on the issue see Perkins (1994) and Campbell and Brown (2003).

\(^{41}\) This factor is also called “pure risk” or “pure time preference”.

\(^{42}\) Current incomes and current consumptions are certain, to the contrary future incomes and future consumptions are uncertain (for instance, individuals take into account death); in developed economies the uncertainty about the future is lower, therefore also the related risk premium should be lower (Campbell and Brown (2003)).

\(^{43}\) This idea is based on the diminishing marginal utility of the income and of the consumption. Each additional euro of wealth contributes less in increasing utility as the total wealth increases. Therefore, if wealth is higher in the future, the marginal utility in spending one euro tomorrow will be lower than the marginal utility in spending one
prefer to receive a given income sooner rather than later, because the available resources can be obviously increased over time through investments which yield positive returns. It follows that the Market Interest Rate (MIR), which is determined by the interaction of demand for and supply\textsuperscript{44} of investable funds is positive and discounting the future is a prevalent practice in theoretical and applied economics\textsuperscript{45}.

For these reasons, monetary costs and benefits should be compared considering the corresponding values in a certain moment, therefore a method to standardize them on a single time dimension is required\textsuperscript{46}. It follows that the methodological issue is twofold:

- How future effects of a project should be discounted?
- What discount rate should be adopted?

Acknowledging the dual nature of the problem, in order to comply with the length limits imposed for this work, this chapter exclusively deals with the second question, trying to explain the main insights resulting from the academic debate on the selection of the discount rate for CBA. Nevertheless, a quick look to the crucial role played by the discount rate in assessing a project adopting the Net Present Value (NPV) techniques is provided in the next paragraph.

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\textsuperscript{44} The demand is determined by the opportunities of investment which are available in a given economy. The supply is just determined by individual preferences for present against future consumption.

\textsuperscript{45} Islam (2002).

\textsuperscript{46} The above discussion does not take into account the inflation. If inflation occurs, in a future moment it will be possible to buy a lower quantity of goods and services with a given amount of money, hence further reducing the utility which results by spending one euro in the future.
3.2. The relation between the selection of the discount rate and the net present value of a project

“[T]he long term interest rate/ Determines any project’s fate/ At two percent the case is clear;/ At three some sneaking doubts appear;/ At four it draws its final breath;/ At five percent is certain death”\(^{47}\).

The most common method used to compare resources available in different moments is the NPV\(^ {48}\). It measures the value of a project calculating the difference between the Present Value (PV) of all future benefits and the PV of all future costs. Therefore, adopting a standard discount scheme\(^ {49}\), the NPV of a project with a lifetime of \( t \) periods is calculated discounting future benefits and costs using a discount rate \( i \):

\[
NPV = \left[ \frac{B_0}{(1 + i)^0} + \frac{B_1}{(1 + i)^1} + \cdots + \frac{B_n}{(1 + i)^n} \right] - \left[ \frac{C_0}{(1 + i)^0} + \frac{C_1}{(1 + i)^1} + \cdots + \frac{C_n}{(1 + i)^n} \right]
\]

\[= \sum_{t=0}^{n} \frac{B_t}{(1 + i)^t} - \sum_{t=0}^{n} \frac{C_t}{(1 + i)^t} \quad (3.1.)^{50}.
\]

As a result, the NPV of a project is strongly influenced by the selection of the discount rate because the higher \( i \) the lower the weight given to benefits and costs occurring in a distant future\(^ {51}\). For instance, the PV of a benefit of €1.000.000.000 which will accrue in 100 years is €369.711.212 at a discount rate of 2%, but it is only €72.566 at a

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\(^{47}\) Poem attributed to Kenneth Boulding and quoted in Heinzerling (1999), p.44.

\(^{48}\) For an historical perspective on the adoption of the NPV method for the evaluation of non-financial investment see Parker (1968). The problem of assessing and choosing different investment options was widely discussed in the 30s by Fisher (1907 e 1930), Boulding (1935), Keynes (1936), Williams (1938) and Samuelson (1937a). For a comprehensive discussion on this issue see Anderson and Russel (1977), Perkins (1994), Nas (1996), Boardman et al. (2006), Pearce et al. (2006), and Mishan and Quah (2007).

\(^{49}\) For an accurate discussion on financial compounding and discounting techniques see Bortot et al. (1993).

\(^{50}\) The same result can be reached computing the PV of the annual NBs of a project: \( NPV = \frac{(R_1-C_1)}{(1+i)^1} + \frac{(R_2-C_2)}{(1+i)^2} + \cdots + \frac{(R_n-C_n)}{(1+i)^n} \).\(^ {1}\)

\(^{51}\) In the Equation 3.1. (supra) the factor \( \gamma = 1/(1+i) \) is the so called discount factor. This is the typical formulation of the well established “exponential” approach to discounting where \( \gamma \), as an exponential function, diminishes as \( t \) increases, thus assigning a lower value to amounts of money which accrue in the distant future.
discount rate of 10%:

\[ PV_{1\%} = \frac{\€1.000.000.000}{(1 + 0,01)^{100}} = \€369.711.212; \]

\[ PV_{10\%} = \frac{\€1.000.000.000}{(1 + 0,1)^{100}} = \€72.566. \]

Mistakes in setting the discount rate can easily determine the death or the life of a project. Considering the example proposed in Tables 3.1. and 3.2. (infra), two main conclusions can be drawn. First, the NPV of the same project can result positive or negative using different discount rates (see project A or C). Second, adopting higher discount rates, which give more value to the time, projects with immediate benefits (see project B) are preferred to projects with distant future benefits (see project C).

As Viscusi\textsuperscript{52} explains, the selection of a high discount rate makes regulatory and legislative policies with long term benefits and short term costs less attractive, thus favoring projects delivering immediate benefits and less capital intensive. To the contrary, low discount rates favor policies which are more “future-oriented” and can result in intergenerational effects, thus better dealing with long term problems such as global warming, climate change, cancer prevention and so on. Therefore, next paragraphs focuses on the academic debate on the choice of the proper discount rate for CBA of public policies.

\textsuperscript{52} Viscusi (1997).
Table 3.1. Cash flows of three different projects

<table>
<thead>
<tr>
<th>Years</th>
<th>Project A</th>
<th>Project B</th>
<th>Project C</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-€ 1.000.000,00</td>
<td>-€ 1.000.000,00</td>
<td>-€ 1.000.000,00</td>
</tr>
<tr>
<td>1</td>
<td>€ 150.000,00</td>
<td>€ 500.000,00</td>
<td>€ 0,00</td>
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<td>€ 50.000,00</td>
<td>€ 1.850.000,00</td>
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</table>

Table 3.2. Net present value of three different projects showed in Table 3.1. using several discount rates

<table>
<thead>
<tr>
<th>Discount rate</th>
<th>Project A</th>
<th>Project B</th>
<th>Project C</th>
</tr>
</thead>
<tbody>
<tr>
<td>0,00%</td>
<td>€500.000,00</td>
<td>€500.000,00</td>
<td>€850.000,00</td>
</tr>
<tr>
<td>2,00%</td>
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<td>€407.823,67</td>
<td>€517.644,37</td>
</tr>
<tr>
<td>3,00%</td>
<td>€279.530,46</td>
<td>€365.752,61</td>
<td>€376.573,77</td>
</tr>
<tr>
<td>4,00%</td>
<td>€216.634,41</td>
<td>€326.077,93</td>
<td>€249.793,75</td>
</tr>
<tr>
<td>7,00%</td>
<td>€53.537,30</td>
<td>€219.655,44</td>
<td>- €59.553,74</td>
</tr>
<tr>
<td>10,00%</td>
<td>- €78.314,83</td>
<td>€129.047,60</td>
<td>- €286.744,81</td>
</tr>
</tbody>
</table>

3.3. The social discount rate: what rate should be adopted?

The choice of a proper discount rate to be adopted in economic planning, project evaluation and public policy formulation can be considered as one of the oldest and most significant issues for scholars who focus their attention on the CBA technique.
Actually, an ultimate solution to this problem is still to be found\textsuperscript{53}.

In financial analyses there is a common agreement on the correct approach to determine the financial discount rate. This rate should result from the estimation of the actual cost of capital borne by the project implementer. To the contrary, in economic analyses, such as CBA of policies, the crucial dispute is on the determination of the appropriate level of the so-called SDR, which should reflect the social opportunity cost of the capital used by the government to fund a given project\textsuperscript{54}. More generally, it should reflect the value that individuals involved in a public project give to the time factor. Therefore, in order to discount the future streams of NBs it is necessary to select a SDR which is appropriate from a society’s perspective\textsuperscript{55}.

3.3.1. Discount rates in a “first best world”

3.3.1.1. A simple model: individual consumption

In order to start dealing with the problem of the selection of the SDR, it is possible to consider a closed and perfect economy, without production, where each individual can consume by just borrowing as much money as he wants at a given market MIR\textsuperscript{56}, \(i\), under a budget constraint. In Figure 3.1. (infra), \(C_1\) represents the consumption of a given individual in year 1, \(C_2\) the consumption of the same individual in year 2. The utility of the individual can be represented as a function of the consumption over the 2 years:

\[
\text{utility} = f(C_1, C_2).
\]

\textsuperscript{53} For further discussions on the issue see Lind (1982).

\textsuperscript{54} Perkins (1994).

\textsuperscript{55} Nas (1996).

\textsuperscript{56} The MIR is determined by the interaction of demand for and supply of investable funds. In a competitive market both suppliers (savers) and consumers (investors) of investable funds are price takers and the equilibrium market clearing price, \(i\), results unique.
The indifference curves \(U_n(C_1, C_2)^{57}\) of this utility function are also represented in the Figure 3.1. (infra). Indifference curves have a negative slope because any individual has to give up some consumption in the year 1 in order to have more consumption in the year 2. The absolute value of the slope of any \(U_n(C_1, C_2)\) is the individual Marginal Rate of Substitution (MRS) between current and future consumption\(^{58}\). The difference MRS-1 represents the Marginal Rate of Time Preference (MRTP), \(p\), that is the rate at which an individual is indifferent between substituting current consumption \(C_1\) for future consumption \(C_2\)^{59}. From a theoretical standpoint, if an individual is indifferent to receive 1 unit of income in year 1 rather than \(1^*(1+p)^{60}\) units in year 2, \(p\) will be the MRTP of the individual. Likewise, the same individual will be indifferent to receive 1 unit in year 2 rather than \(1/(1+p)^{61}\) unit in year 1. Therefore for any individual the proper discount rate to use in investment decisions is his MRTP\(^{62}\).

Any individual aims at maximizing his utility under a budget constraint which is represented by the total possible current consumption, a quantity equals to \(T^{63}\).

Theoretically, an individual starts form the point \(T\) on his budget constraint, which is the point where he consumes all the resources in the current year, and then exchanges on the market current consumption for future consumption at the rate \(i\), if higher than his MRTP. The optimal mix of current and future consumption occurs when the slope of the budget constraint, \(-(1+i)\), is equal to the slope of the indifference curve, \(-(1+p)\).

\(^{57}\) \(U_1(C_1, C_2)\) and \(U_2(C_1, C_2)\) represent indifference curves with \(U_2\) preferred to \(U_1\). Individuals are indifferent to any point of consumption on the same indifference curve which, in this circumstance, represents a combination of present and future consumption.

\(^{58}\) If in a given point MRS is equal to 1,1, an individuals will be willing to accept 1,1 units of future consumption in exchange for 1 unit of current consumption.

\(^{59}\) The slope of \(U_n(C1, C2)\) in a given point is equal to \(-(1+p)\), therefore MRS=1+p and MRTP=MRS-1=p.

\(^{60}\) Single period compounding formula.

\(^{61}\) Single period discounting formula.

\(^{62}\) Perkins (1994).

\(^{63}\) \(T\) is the PV of the total income over the 2 years: \(T=C1+(C2/(1+i))\), with \(i\) equals to the MIR. The equation of the budget constraint can be written as \(C2=T(1+i)-(1+i)C1\), where the constant negative slope is \(-(1+i)\).
Therefore, in the equilibrium point $A$, $i$ is equal to $p$, i.e. the MRTP is equal to the MIR and the individual’s utility is maximized, given the budget constraint, with optimal quantity of consumption $C_1^*$ and $C_2^*$\(^{64}\). For such a reason, in equilibrium the SDR equals the MIR which in turn equals the MRTP.

Figure 3.1. Discount rate in the “first-best world”: individual consumption model

3.3.1.2. A more complex model: social production and consumption

The more complex model showed in Figure 3.2. (infra) takes into account the Production Possibility Curve (PPC)\(^{65}\) and the aggregate consumption of the whole society over a 2 years period. PPC is concave because of the diminishing returns of investments. $T$ still represents the maximum current consumption of the population in the year 1, while $S$ represents the maximum future consumption in the year 2, given

\(^{64}\) Excluding people with extreme consumption preferences (corner solution can be possible in theory, with $C_1$ or $C_2$ alternatively equal to 0), in a perfect market each individual has an MRTP equals to the MRI, because all individuals face the same $i$ (price takers).

\(^{65}\) PPC represents the society’s ability to convert today consumption into tomorrow consumption through investments (Nas (1996)).
the shape of the PPC\textsuperscript{66}. The absolute value of the slope of the PPC, -(1+r), is called Social Marginal Rate of Transformation (SMRT)\textsuperscript{67} and the Social Marginal Rate of Return on Private Investment (SMRRPI), r, is equal to the difference SMRT-1\textsuperscript{68}.

**Figure 3.2. Discount rate in the “first-best world”: social production and consumption model**

Any point on each Social Indifference Curve (SIC\textsubscript{n}), as well as on the individual indifference curves of the previous simpler model, is a combination of current and future consumption that keeps the society on the same level of social utility\textsuperscript{69}. The absolute value of the slope of SIC is the Social Marginal Rate of Substitution (SMRS)\textsuperscript{70}, 1+p, with p equals to the Social Marginal Rate of Time Preference, SMRTP\textsuperscript{71}, i.e. the

\textsuperscript{66} It results that S is higher than T because investments give back additional resources to be consumed.

\textsuperscript{67} If in a given point SMRT is equal to 1,1, society will be able to invest 1 unit of present consumption obtaining 1,1 units of future consumption, with a marginal rate of return on the investment of 0,1.

\textsuperscript{68} Nas (1996). This rate, r, can be considered also as the marginal productivity of capital (Perkins (1994)).

\textsuperscript{69} SIC\textsubscript{3} is preferred to SIC\textsubscript{2} that is preferred to SIC\textsubscript{1}, but the society is unable to reach SIC\textsubscript{3} considering the existing PPC.

\textsuperscript{70} It is the MRS for the whole society.

\textsuperscript{71} It is the MRTP for the whole society.
extra amount of future consumptions that society requires to give up one unit of current consumption.

A country aims at maximizing its social utility reaching the highest SIC\textsubscript{m}, given the existing PPC. Therefore, moving along the PPC, the optimal point is represented by \( A \) where \( C_1^* \) units are consumed in year 1 and \( C_2^* \) are consumed in year 2. In equilibrium the slope of the SIC\textsubscript{m}, \(-1+p\), is equal to the slope of the PPC, \(-1+r\), so the SMRTP, \( p \), is equal to the SMRRP, \( r \). Hence, summing up the findings of the two previous models, in equilibrium the MIR equals to the SMRTP that equals the SMRRP\textsuperscript{72}. As a result, in a perfect market, the MIR is the appropriate SDR for any CBA.

3.3.2. The social discount rate in a “second-best world”

3.3.2.1. Real economies are not a “first-best world”

Real economies are far from the “first-best world” and several distortions affect the capital market. The distorting effects of taxes and public debt have been described by Harberger\textsuperscript{73} (see Figure 3.3., infra) who analyzes a closed domestic market for investments and savings\textsuperscript{74}.

In the absence of taxes, the private supply of capital is \( S_0 \) (lenders) and the private demand of capital is \( D_0 \) (borrowers), therefore the MIR equals \( i \) (as in the “first-best world”). In order to finance government spending, taxes are necessary. By introducing

\textsuperscript{72} In case of perfect capital market, any individual in a given economy has the same MRTP, which equals to the SMRTP and to \( i \). If someone has MRTP>\( i \), he will borrow at \( i \), thus increasing his current consumption and decreasing his MRTP until MRTP will become equal to \( i \). If someone has MRTP<\( i \), he will lend at \( i \), thus decreasing is current consumption and increasing is MRTP until MRTP will become equal to \( i \). In the long run everyone will have the same MRTP, which will be equal to \( i \) and, in the equilibrium point \( A \), to \( r \) (Perkins (1994)).

\textsuperscript{73} Harberger (1969, 1972a, and 1972b).

\textsuperscript{74} The author does not consider transaction costs which actually are an additional distortion.
a corporate tax, the demand for investment shifts leftward from $D_0$ to $D_1^{75}$. Moreover, by introducing an income tax, also the supply of savings shifts leftward from $S_0$ to $S_1^{76}$. Therefore, the new MIR, $i'$, is the equilibrium price of capitals given $D_1$ and $S_1$. The SMRPI before taxes is $r>i'$ because firms have to pay a corporate tax to the government. Instead the SMRTP after taxes is $p<i'$ because savers have to pay an income tax to the government. It follows that the introduction of taxes leads to a situation where SMRPI is higher than MIR which in turn is higher than SRTP.

Figure 3.3. Discount rates in a “second-best world”: tax and public debt distortions in a closed economy

---

75 Investors will be willing to borrow less because their post-tax returns will be lower than their pre-tax returns on investments.

76 Savers will be willing to save less because their post-tax returns will be lower than their pre-tax returns on savings.
An additional way to finance government spending is represented by public debt. Therefore, to fund a public project, government can demand capital in the domestic market thus affecting the market operations. Government borrowings push rightward the demand curve from $D_1$ to $D_2$, raising the MIR to $i''$. As a result, private investments fall (segment $\Delta I$) because marginal investors will be squeezed out of the market. To the contrary, private savings increase (segment $\Delta C$, which corresponds to an equivalent reduction in consumptions)\(^{77}\). It follows that in a closed economy the funding of a public project is likely to displace both private investments and domestic consumptions. The magnitude of the crowding-out effect depends on the relative elasticity of demand for investments and supply of savings.

These divergences between “first-best world” and real economies make the choice of the most appropriate SDR for a CBA of public projects very complicated, thus resulting in disagreement among scholars. One possible option, for instance, could be to choose the rate of return to private investment, i.e. the SMRRPI, assuming that the return to public projects should be higher than or equal to the private rate of return. Another option could be to choose the SMRTP because all future costs and benefits converge into future consumptions, therefore consumers' preferences should be the main determinant of public investment decisions. Furthermore, considering an open economy, also the capital price on international markets would be a significant variable to be taken into account in order to select the SDR. Finally, also alternative methods, based on a weighted approach, which take into account both SMRRPI and

---

\(^{77}\) The sum of the two segments $\Delta I$ and $\Delta C$ corresponds to the amount of capital required to undertake the public project funded exclusively with borrowings (Nas (1996)).
SMRTP (and the international capital price) in discounting future benefits and costs should be considered\(^78\).

### 3.3.2.2. The social marginal rate of return on private investment (\(r\))

The SMRRI, \(r\), could be used as SDR on the assumption that government takes resources out of the private sector, crowding-out private investments. In this case, only public activities yielding a rate of return in excess of the one available in the private sector will be undertaken\(^79\). This approach, also known as social opportunity cost because private investments represent the best alternative use of the resources involved in a public project, is suggested by Hirshleifer\(^80\), Stockfish\(^81\), Mishan\(^82\), and Hargberger himself\(^83\).

In his early works, Harberger argues that savings are not very responsive to variations of the MIR. Empirical evidences\(^84\) show that the domestic supply of savings (represented by curve \(S_1\) in the Figure 3.3., \textit{supra}) may be inelastic at \(i\), therefore the displacement of domestic consumption is insignificant (the length of the segment \(\Delta C\) is close to 0). In this circumstance, public projects crowd out only private investments, so the SMRRPI results as a good proxy for the estimation of the SDR.

As possible numerical value for \(r\), Boardman\(^85\) and Nas\(^86\) suggest the pre-tax rate of return on corporate bonds. Nevertheless, Boardman\(^87\) points out several criticisms in the estimation of SDR using the SMRRI:

\(^{78}\)Nas (1996).
\(^{79}\)Anderson and Russel (1977).
\(^{80}\)Hirshleifer, DeHaven, and Milliman (1960).
\(^{81}\)Stockfish (1969).
\(^{82}\)Mishan (1971).
\(^{83}\)Harberger (1969 and 1972b).
\(^{84}\)Hall (1988) and Muellbauer and Lattimore (1995).
\(^{85}\)Boardman et al. (2006).
\(^{86}\)Nas (1996).
\(^{87}\)Boardman et al. (2006).
• $r$ includes a default risk premium higher than the risk premium associated to governments\textsuperscript{88},

• public projects can be financed also through taxes (and in this case crowding-out of the consumptions is more likely) or by foreign capitals;

• even in case that government borrowings are able to raise the MIR, if a given economy is not fully employing its resources then a complete crowding-out effect is unlikely to occur.

In conclusion, the authors\textsuperscript{89} suggest using the SMRRPI as an upper limit for the estimation of the SDR.

3.3.2.3. The social marginal rate of time preferences ($p$)

The SMRTP (see paragraph 3.3.1.2., supra) expresses the indication of the society's collective preferences between current and future consumption\textsuperscript{90}. The adoption of the SMRTP to estimate the SDR is suggested by Sen\textsuperscript{91}, Marglin\textsuperscript{92}, Arrow\textsuperscript{93} and Kay\textsuperscript{94}. A practical way to justify the use of this rate as a proxy for the SDR is to assume that a project is entirely financed with domestic taxes, moreover assuming that these taxes reduce national consumptions without affecting private investments\textsuperscript{95}.

As possible numerical value for $p$, Boardman\textsuperscript{96} and Nas\textsuperscript{97} suggest the after-tax return

\textsuperscript{88} Arrow and Lind (1970) argue that public projects can be considered as risk-free, therefore the SDR should be lower than the SMRRPI.
\textsuperscript{89} Boardman et al. (2006).
\textsuperscript{90} Islam (2002).
\textsuperscript{91} Sen (1961).
\textsuperscript{92} Marglin (1963a and 1963b).
\textsuperscript{93} Arrow (1966).
\textsuperscript{94} Kay (1972).
\textsuperscript{95} Revesz (1999) explains that this assumption is realistic for environmental regulation in an open economy such as the US one.
\textsuperscript{96} Boardman et al. (2006).
\textsuperscript{97} Nas (1996).
on savings and, because it is appropriate to discount at a risk free\textsuperscript{98} rate, the more suitable rate could be the return to government bonds. Also in this case, Boardman\textsuperscript{99} points out several criticisms in the estimation of SDR using the SMRTP:

- individuals differ in preferences and opportunities therefore the SMRTP is not equal to MRTP and problems of estimation exist\textsuperscript{100};
- many individuals, at the same time, pay back interests on mortgages, buy government and corporate bonds and stocks, borrow on the credit card, and so on, at different interest rates, so it is likely that even the same individual considers different MRTP in his consumption choices;
- public projects can be financed also through government debt (and in this case the crowding-out of the investments is more likely) or by foreign capitals;
- $p$ can be much lower than $r$ thus justifying projects with very low returns at the expense of feasible higher returns from private projects (opportunity cost), thereby harming efficiency\textsuperscript{101}.

As a result the SRTP is suitable to be a lower limit for the estimation of the SDR.

3.2.2.4. The government borrowing rate on international markets ($i_{int}$)

The Harberger’s model (see paragraph 3.3.2.1., \textit{supra}) considers a closed domestic economy. Nevertheless, in an open economy governments can borrow money on the

\textsuperscript{98} Future benefits and costs should have already been calculated as expected value.

\textsuperscript{99} Boardman et al. (2006).

\textsuperscript{100} As explained by Perkins (1994), several problems are associated with the derivation of the SDR form individual MRTP: irrationality of inter-temporal consumption decisions, lack of inter-generational considerations, prisoner’s dilemma argument in consumption decisions, and divergences between pre-tax and post-tax MRTP.

\textsuperscript{101} Also Anderson and Russel (1977) point out that using two different rates for public and private investments could lead to allocative inefficiency in the current use of resources.
international market, reducing or even avoiding the crowding-out effect on national consumptions and private investments. An analysis of the selection of the discount rate in an open economy is carried out by Edwards\textsuperscript{102} and Lind\textsuperscript{103}.

For such a reason, another plausible value to approximate the SDR is the government long-term borrowing rate on the international markets, \( i_{\text{int}} \). This rate reflects the actual cost that decision-makers face to fund marginal projects borrowing from foreign capital markets. This solution is feasible on the assumption that government can access the international capital market\textsuperscript{104} and that the beneficiaries of the assessed project can be taxed to pay back the interests and the loan.

As possible numerical value for \( i_{\text{int}} \), Perkins\textsuperscript{105} suggests the interest rate at which a country is able to borrow on international market, that can be approximated by the London Inter-bank Borrowing Rate (LIBOR) or likewise by the EURo Inter Bank Offered Rate (EURIBOR), plus a premium due to the country risk.

Boardman\textsuperscript{106} points out the following criticisms in using this rate to estimate the SDR:

- it is unrealistic that only the beneficiaries of a project pay taxes to pay back a foreign debt;
- an increase in government borrowings will affect also the domestic MIR, thus crowding out also some private investments and some domestic consumptions.

\textsuperscript{102} Edwards (1985).
\textsuperscript{103} Lind (1990).
\textsuperscript{104} The international supply curve should be infinitely elastic (horizontal curve), therefore a change in the demand curve (rightward shifting due to the public project) does not affect the capital price, \( i_{\text{int}} \).
\textsuperscript{105} Perkins (1994).
\textsuperscript{106} Boardman et al. (2006).
3.2.2.5. **The weighted social opportunity cost of capital**

The weighted opportunity cost technique to estimate the SDR is introduced in the early 70s by Harberger 107, Dreze and Sadmo 108. In his original approach, Harberger 109 (see Figure 3.3., supra) suggests the computation of a weighted average of \( r \) and \( p \), considering as weights the respective size of the crowding-out effect on investments and consumptions due to funding the project 110:

\[
SDR = x \cdot r + y \cdot p \quad (3.2),
\]

where

\[
x = \frac{\Delta I}{\Delta I + \Delta C} \quad (3.3),
\]

and

\[
y = \frac{\Delta C}{\Delta I + \Delta C} \quad (3.4).
\]

Edwards 111 and Boardman 112 suggest an additional addend for the Equation 3.2. (supra), on the assumption that in an open economy part of the resources necessary to fund a public project can be borrowed on the international capital market. As a result, the equation of the Weighted Social Opportunity Cost of Capital (WSOCC) should be the following:

\[
SDR = x \cdot r + y \cdot p + z \cdot i_{int} \quad (3.5),
\]

where

\[
z = 1 - x - y \quad (3.6),
\]

and

\[x + y < 1 \quad (3.7)\]

---

107 Harberger (1969, 1972a, and 1972b)
108 Dreze and Sadmo (1971) and Dreze (1974).
110 The following equations are a simplified interpretation of the main findings of Harberger. In the original equations a central role is played by the elasticity both of supply of savings and of demand for investable funds.
112 Boardman et al. (2006).
113 In this circumstance the amount of money necessary to fund the project is higher than the sum of the segments \( \Delta I \) and \( \Delta C \). The residual part is obtained on the international capital market.
Assuming that \( p < i_{int} < r \), the WSOCC is higher than the \( p \) and lower than \( r \), therefore SMRTPI<SDR<MRRPI. Actually, the value of the weights \( (x, y, \text{ and } z) \) depends on the way a specific project is funded and, in practice, the estimation of the parameters \( x, y \) and \( z \) is rather difficult to be obtained.

### 3.3.3. The shadow price of capital

Conceptually one unit of money invested today leads to a given return tomorrow. This return can be totally reinvested, totally consumed or partially reinvested and partially consumed. Therefore, crowding-out one unit of private investment is equivalent to displace an additional stream of future investments or consumptions. Likewise, allowing one unit of additional private investment is equivalent to enable an additional stream of future investments and consumptions. The underlying idea of the Shadow Price of Capital (SPC) method is to convert the amount of private investments which are crowded out or which are fostered by a public project in a stream of future consumptions, thus ultimately estimating the total amount of consumptions displaced or enabled by current public investments.

This method, introduced by Marglin and Feldstein, allows to convert all future benefits and costs of a public project into consumption equivalents. The conversion is made using an adjustment factor \( \theta \), that represents the PV of the future consumptions which would result from investing one unit of money in the private sector. On the assumption that a private investment leads, per each unit invested, to a

---

\(^{114}\) Perkins (1994).
\(^{115}\) Nas (1996).
\(^{116}\) Marglin (1963 a, 1963b, and 1967).
\(^{117}\) Feldstein (1964).
\(^{118}\) Actually this parameter is the SPC sensu stricto.
return of $r$ in each future period (perpetuity), and that all the earned returns are entirely consumed in each future period, the PV of this consumption perpetuity should be discounted using $p$. It follows that the adjustment parameter could be computed as\footnote{This formula to compute $\theta$ is suggested by Marglin, Sen and Dasgupta in the UNIDO Guidelines (1972).}:

$$\theta = \frac{r}{p} (3.8)^{120}. \tag{3.8}$$

Moreover, considering that the future returns could be partially reinvested, $s$\footnote{Considering that $r \gg p$ then $\theta \approx 1$, therefore crowding out investments is more costly for society than displacing consumptions.}, and partially consumed, $(1-s)$, the equation of the adjustment parameter should consider that annually the stock of invested capital increases\footnote{$s$ is the fraction of the gross return which is actually reinvested.}:

$$\theta = \frac{r(1-s)}{p - r \cdot s} (3.9). \tag{3.9}$$

A more general equation to calculate the SPC is suggested by Boardman\footnote{This formula is valid if $p \gg s$.}, who considers also the annual depreciation rate of the invested capital, $\delta$, which diminishes the stock of capital:

$$\theta = \frac{(r + \delta)(1-s)}{p - r \cdot s + \delta(1-s)} (3.10). \tag{3.10}$$

After the estimation of $\theta$, the SPC approach can be applied through four sequential steps:

- future costs and benefits of a project are divided in those affecting directly

\[\text{\footnotesize\ref{119} This formula to compute $\theta$ is suggested by Marglin, Sen and Dasgupta in the UNIDO Guidelines (1972).} \]
\[\text{\footnotesize\ref{120} Considering that $r \gg p$ then $\theta \approx 1$, therefore crowding out investments is more costly for society than displacing consumptions.} \]
\[\text{\footnotesize\ref{121} $s$ is the fraction of the gross return which is actually reinvested.} \]
\[\text{\footnotesize\ref{122} This formula is valid if $p \gg s$.} \]
\[\text{\footnotesize\ref{123} Boardman et al. (2006).} \]
consumption and in those affecting private investments\textsuperscript{124};

- the ones affecting private investments are multiplied by $\Theta$, therefore converted in consumption equivalents;

- variation in consumption equivalents are added to direct variation in consumptions;

- all the resultant flows are discounted at the SMRTP $p$, which actually reflects the rate at which society is willing to postpone current consumptions.

As a result, this method has a strong theoretical appeal, but it is difficult or even impossible to use in practice\textsuperscript{125}.

Boardman\textsuperscript{126} points out several criticisms in the application of the SPC:

- this instrument is by far more complex than the simple estimation of an SDR;

- substantial information, including the value of $r$ and $p$, are required to calculate $\Theta$;

- assumptions play an important role in the allocation of future costs and benefits between consumption and investment displacement or promotion, therefore this approach could be easily applied incorrectly or manipulated to reach political targets.

\textsuperscript{124} In order to use the SPC it is important to measure to which extent private investments are likely to be displaced or increased by the analyzed public project.

\textsuperscript{125} Perkins (1994).

\textsuperscript{126} Boardman et al. (2006).
3.3.4. The optimal growth rate approach

The father of the "optimal growth rate method" to select the SDR is Ramsey\textsuperscript{127}. Boardman\textsuperscript{128} refers to Ramsey’s framework proposing a model where a given society receives utility from consumption and discounts the future for two different reasons: any individual prefers current consumption over future; economic growth exists.

In the absence of economic growth, society takes into account only the individual preferences for current over future consumption, therefore the SMRTP is a pure rate of time preference, $d$\textsuperscript{129}. It is important to underline that, without economic growth, applying $d$ to discount long run project is equivalent to consider the utility of future generations less valuable than the one of the current generation\textsuperscript{130}. To the contrary, with economic growth and decreasing marginal utility of consumption, future generations will have greater opportunity of consumption thus assigning less value to the utility of additional consumptions. For such a reason society will discount future consumptions considering the economic growth\textsuperscript{131} as well as the pure rate of time preference. Therefore the SMRTP will be:

$$p = d + g \cdot e \ (3.11);$$

where $e$ is the elasticity of the of the marginal utility of consumption to the increase of per capita consumption\textsuperscript{132} and $g$ is the long-run growth rate of per capita consumption. It follows that, given $e$ and $d$, the higher will be $g$, the higher will be $p$,

\textsuperscript{127} Ramsey (1928).
\textsuperscript{128} Boardman et al. (2006).
\textsuperscript{129} It is the “utility discount factor" described above (see paragraph 3.1., supra).
\textsuperscript{130} The intergenerational discounting issue is tackled in the paragraph 3.4., infra.
\textsuperscript{131} It is the “utility growth factor" described above (see paragraph 3.1., supra).
\textsuperscript{132} It measures how fast the social marginal utility of consumption falls as per capita consumption grows.
hence the lower will be the weight that should be given to future generation consumptions in order to ensure intergenerational equity.

Moreover, Ramsey\textsuperscript{133} shows that, given the optimal growth path of the economy, the value of the SMRRPI must equal the value of the SMRTPI:

\[ r = p = d + g \cdot e \ (3.12). \]

This equation enables scholars to derive the SDR from the solution of an optimum growth model, thus computing the discount rate which determines the optimal allocation between consumptions and savings\textsuperscript{134}. This approach is based on the assumption that analysts are able to draw a well-behaved social welfare function (which accurately describes the values that society puts on different amounts of per capita consumptions over time) and, subsequently, to choose the amount of public investments which maximize the current and the future well-being of the society\textsuperscript{135}.

Boardman\textsuperscript{136} points out several criticisms of the “optimal growth rate” approach to discounting:

- the estimation of \( g \) is inaccurate both because historical statistical data on consumption or GDP may include also investment goods (and not only consumption) and because historical data cannot provide any indication on the future long-run growth rate;
- the estimation of \( e \) is inaccurate both because based on a value judgment about intergenerational equity and because it is difficult to aggregate

\textsuperscript{133} Ramsey (1928).
\textsuperscript{134} Islam (2002).
\textsuperscript{135} Boardman et al. (2006).
\textsuperscript{136} Ibidem.
individual preferences about equity;

- the estimation of \( d \) is inaccurate because it requires a value judgment on the pure time preference of the whole society;
- finally, if \( p \) is lower than \( r \), then private projects could increase social welfare more than public ones.

Undoubtedly, the estimation of the SDR with this approach involves substantial value judgments. This method becomes even more problematic if an economy is experiencing a negative consumption growth rate, and environmental degradation and resource exhaustion are taking place. In these circumstances, the future generations will not be better off, undermining the main assumption of the theory of the optimal economic growth and providing room for the debate on the intergenerational discounting.\(^{137}\)

### 3.4. The intergenerational discounting problem

The current academic debate on the SDR is mainly focused on the intergenerational discounting problem. On the one hand, some scholars argue that future costs and benefits should be discounted using a rate which exclusively takes into account the preferences of the present generation. On the other hand, other scholars argue that the SDR used by the government should incorporate also the welfare of future generations.

#### 3.4.1. The focus on the present generation

A great part of the academic debate on the intergenerational discounting assumes that

\(^{137}\) Islam (2002).
individuals are self-interested and that they take care only of their own future, with no concern for future generations. Nevertheless, there are evidences that people consider the needs of posterity in their choices. Therefore, to the extent to which these needs are already embedded in market behaviors, the necessity for an adjustment of the MIR in the CBA becomes less significant\textsuperscript{138}.

From a different perspective, Sunstein and Rowell\textsuperscript{139} argue that the debate on the intergenerational equity should not focus on the discounting topic. Future benefits and costs of any project are monetized and there is a common agreement on the fact that money have to be discounted in order to compare their value in a given time period. Therefore, the selection of the SDR should be based just on individual preferences, not on government decisions. Undoubtedly, people preferences showing little concern for the future generations might be questioned and moral obligations to posterity should be fulfilled by current generation. Nevertheless, this argument should not affect the selection and the use of the discount rate in CBA and the intergenerational equity problem should be faced directly\textsuperscript{140}.

Posner\textsuperscript{141} expresses an even more extreme position. He explicitly asserts that, even if it could seem ethically inappropriate, public agencies should not consider the needs of distant-future generations. He points out two considerations to support his argument: a democratic government should take into account the needs of voters, which do not include future generations; public agencies just exercise a delegated power in order to

\textsuperscript{138} Campbell and Brown (2003).
\textsuperscript{139} Sunstein and Rowell (2007).
\textsuperscript{140} This problems should affect, ex ante, the monetization of future benefits and costs which can actually be underestimated by analysts. In particular the difference between the current willingness to pay and the future willingness to pay in order to avoid a future harms should be stressed.
\textsuperscript{141} Posner (2007).
maximize the welfare of the current generation\textsuperscript{142}. It follows that the weight given to future generations should be the one fixed by voting members of the current generation. Furthermore, the author makes an analogy between future generations and foreigners. Therefore, as American value the well-being of foreigners less than 1/2000 of the well-being of American citizens\textsuperscript{143}, the SDR used to evaluate regulatory projects should be higher than the SMRRPI and, beyond 30 or 50 years\textsuperscript{144}, it should become equal to infinity.

3.4.2. The focus on the future generations

To the contrary, Sen\textsuperscript{145} points out three main arguments in favor of a SDR lower than the rate of time preference of the current generation in order to compute the NPV in a CBA of public project:

- \textit{The super-responsibility argument}. Government is responsible for posterity's welfare “over and above” the concern for future generations expressed by the current generation’s preferences;

- \textit{The dual-role argument}. An individual as citizen is more concerned about the future generations' welfare than the same individual as consumer;

- \textit{The isolation argument}. Individuals are willing to increase their savings and to reduce their consumptions only if all the members of the society to which they belong are committed in doing the same. In other words, if individuals are bound by a “collective contract” to save more, they will be

\textsuperscript{142} Actually Posner (2007) refers to American public agencies and to the current generation of Americans.
\textsuperscript{143} Kopczuk, Slemrod, and Yitzhaki (2005); the value refers to foreigners who live in the poorest countries.
\textsuperscript{144} This is the distant-future horizon for Posner (2007).
\textsuperscript{145} Sen (1982).
willing to increase their savings for future generations; to the contrary, if they act as single members of a society (isolation), they will be unwilling to save more.

Also Revesz and Livermore\textsuperscript{146} argue that discounting benefits and costs which affect future generations might raise moral issues. From this viewpoint, the current practice to use a constant discount rate, which takes into account the MIR, is misleading because it is based on the assumption that present generation is worth more than future ones. The two authors argue that politicians are unwilling to face this intergenerational problems for two main reasons:

- \textit{Time horizon of electoral politics}. The costs of long-run policies are usually borne by the current electorate while the benefits will accrue only in the future.

- \textit{Geographical horizon}. The costs of many intergenerational public policies, such as the ones related to climate changes or to sustainable development, are directly borne by the local electorate, while the benefits can be registered worldwide.

As a result, Revesz and Livermore\textsuperscript{147} explain that the use of a constant and relatively high SDR in the CBA, leading to a negative cost-benefit test for many projects with long-run benefits\textsuperscript{148}, represents just a justification to the inaction of the government and public agencies in developing pro-environmental regulations and projects. They

\textsuperscript{146} Revesz and Livermore (2008).
\textsuperscript{147} \textit{Ibidem}.
\textsuperscript{148} Anderson and Russel (1977) underline that the adoption of a too high discount rate results in penalizing projects which involve long run benefits (dams, highway) and in favoring projects which involve long run costs (nuclear plants, toxic wastes, ...).
refer to this issue as a “convenient untruth”, a practical solution which hides a significant moral decision on intergenerational responsibilities.

Actually, the acknowledgement of this moral problem can be already found in Ramsey\textsuperscript{149}, who explains (see paragraph 3.3.4., supra) that the pure rate of time preference, $d$, should be equal to 0\textsuperscript{150}. In the Ramsey formula, the intergenerational problem is overcome considering the economic growth as the main justification to discount the future. This argument is based on the strong assumption that beneficiaries in the future will be better off than the current individuals burdened by the costs of a new policy. Undoubtedly, this assumption may be unrealistic. First of all an economy can register stagnation or negative growth. Second, for some long-run regulatory or legislative policies, such as the one referred to the environment, the main costs are borne only by developed countries, while the benefits are borne also by developing and under-developed countries where future consumption level could still be lower than the current consumptions of wealthier countries\textsuperscript{151}. To conclude, it is important to underline that this stream of thought could also lead to the claim for 0% discounting or even for a negative value for the SDR.

### 3.4.3 A time-declining social discount rate

A more equilibrate approach to the intergenerational discounting problem is suggested by Pearce\textsuperscript{152} who underlines that the “conventional” approach, based on a

\textsuperscript{149} Ramsey (1928).

\textsuperscript{150} This is an equitable consideration which shares the resources in half between the current and the future generation.

\textsuperscript{151} It is equivalent to say that the marginal utility of consumption of many future beneficiaries of the public project will be equal to or even higher than the marginal utility of consumption of individuals who bear the costs of the project.

\textsuperscript{152} Pearce et al. (2006).
constant and positive SDR, represents just one of the possible assumptions\textsuperscript{153}, and not necessarily the best. Therefore, considering the issue of the hyperbolic discounting\textsuperscript{154}, the uncertainty about future interest rates\textsuperscript{155} and about the future state of the economy growth\textsuperscript{156}, and the problem of the “tyranny” of one generation on another\textsuperscript{157}, Pearce\textsuperscript{158} advocates the application of a time-declining discount rate\textsuperscript{159}. As a result, lower discount rates should be used for costs and benefits which occur later in the future than for those which occur sooner. Also Boardman\textsuperscript{160} points out several reasons to use a time-declining SDR, underlining that a lower rate should be adopted when future streams of benefits and costs cross an intergenerational line fixed at 50 years.

3.5. The sensitivity analysis for the social discount rate

In any CBA, analysts make operational assumptions in order to estimate benefits, costs, project lifetime, discount rates and so on. Some of these assumptions could be not accurate or sufficiently reliable, thus leading to a situation of uncertainty\textsuperscript{161}. Several methods have been developed to deal with risk and uncertainty in CBA. Sensitivity analysis\textsuperscript{162} is one of the most common procedure used by analysts. In practice, a range of plausible values for each significant variable is tested in order to

\textsuperscript{153} Exponential discounting based on a constant and positive discount rate is an axiom not empirically verified (Samuelson (1937b)).

\textsuperscript{154} Empirically, individuals’ discount rates seems to be “time varying”, declining as time passes; for further academic discussions on the issue see Thaler (1981), Cropper et al. (1992), and Frederick et al. (2002).

\textsuperscript{155} Weitzman (1998); for further discussions on the issue see also Newell and Pizer (2003).

\textsuperscript{156} Gollier (2002).

\textsuperscript{157} Chichilnisky (1996).

\textsuperscript{158} Pearce et al. (2006).

\textsuperscript{159} This approach can result in problems of time (or dynamic) inconsistency. With a time declining SDR, the NPV of a project, \textit{ceteris paribus}, depends on the moment in which the appraisal is made. For instance, a given future benefit or a future cost that today is discounted at a rate \(i_t\), next year could have to be discounted at a rate \(i_{t+1}\) with \(i_{t+1} > i_t\), therefore affecting the NPV. The risk is that future reassessment of an undertaken project will lead to a judgment of dismissal before its completion (see Winkler (2006) and Hansen (2006)).

\textsuperscript{160} Boardman et al. (2006).

\textsuperscript{161} Nas (1996).

\textsuperscript{162} Also known as sensitivity testing.
measure to which extent CBA results are sensitive to variations of the main analytical assumptions.

As showed in paragraph 3.2. (supra), the discount rate selected to compute the NPV can have a significant effect on the results of a CBA. Nonetheless, the academic debate has not reached a consensus on the most appropriate SDR to be adopted in a CBA of public project. For these reasons, in this context of uncertainty, the application of a partial sensitivity analysis\textsuperscript{163} to the SDR used in a CBA is highly recommended. The most simple approach is based on the adoption of at least two different values for the SDR, thus checking for the effects on the NPV\textsuperscript{164}. If the sign and the ranking (in case mutually exclusive projects are compared) of the NPV are unaffected by the sensitivity test, then the CBA will be “robust” and the underlying policy recommendations will be more sound. Otherwise, if the results of the CBA are altered, then judgments about the reasonableness of the selected SDR will be required and analysts should highlight the sensitivity issue\textsuperscript{165}. For instance, considering a sensitivity analysis of the projects evaluated in Tables 3.1. and 3.2. (supra) using as discount rate 3\% and 7\%: A and B are robust projects; C is not robust because the NPV is positive at 3\% and negative at 7\%; the ranking to select the best option is not robust because at 3\% C is the preferred alternative while at 7\% B is preferred. In these circumstances, a decision on the best option to undertake should be definitely left to the policy-makers.

\textsuperscript{163} A partial sensitivity analysis is applied only to the variables or parameters that the analysts consider the most significant for the CBA.

\textsuperscript{164} Anderson and Russel (1977).

\textsuperscript{165} Pearce et al. (2006).
3.6. Summing-up

Acknowledged the importance to discount future benefits and costs and the crucial role played by the discount rate in the assessment of a project adopting the NPV method, the academic debate focuses on the selection of the most appropriate SDR to be used in a CBA of public projects. Several approaches are proposed (SMRRPI, SMRTP, government borrowing rate on international market, WSOCC), whose adoption mainly depends on the crowding-out effect generated by the project funding. A strong theoretical appeal is attributed to the SPC technique, nevertheless its application is rather difficult considering the significant estimation problems for the variables involved; the same flaw affects the optimal growth rate approach. The recent debate is centered on the intergenerational discounting issue, i.e. on the necessity of either taking into account or disregarding the needs of future generations in the selection of the SDR, even casting some doubts on the use of a positive SDR. Undoubtedly, although some SDRs are more suitable than others in particular circumstances, a consensus among scholars on the SDR topic is far to be reached, therefore sensitivity analysis provides a workable solution to the uncertainty related to the discount rate adopted in a CBA.
Chapter 4. The role of the discount rate in the cost-benefit analysis: empirical evidences

4.1. The discount rate suggested by legislative and regulatory authorities: a survey

This chapter focuses on the role of the discount rate in the legislative and regulatory practice. In the paragraph 4.1. the regulators’ perspective is considered, providing a survey of the recommendations on discounting issued by public authorities in USA and in EU.

4.1.1. United States of America

In the current section, the US RIA world is examined. The analysis focuses on: the recommendations included in the Circular A-94 and A-4 of the Office of Management and Budget (OMB); the “Guidelines for Preparing Economic Analysis” of the Environmental Protection Agency (EPA); the “Regulatory Analysis Guidelines” of the Nuclear Regulatory Commission (NRC); the “Discount Rate Policy” of the Government Accountability Office (GAO); and the “2011 Long-Term Budget Outlook” of the Congressional Budget Office (CBO).

4.1.1.1. The Office of Management and Budget

The Circular A-94 of the 29th of October 1992 provides OMB’s guidance for the CBA of Federal Programs\(^{166}\). The real discount rate suggested for the base-case analysis is

\(^{166}\) The Circular A-94 (29/Oct/1992) specifically applies also to RIA.
equal to 7\%^{167}. This value “approximates the marginal pretax rate of return on an average investment in the private sector in recent years”\textsuperscript{168}. Furthermore, a sensitivity analysis on the plausible variations of the discount rate is required, considering in particular “the specific economic characteristics of the program under analysis”\textsuperscript{169}. From a theoretical standpoint, the SPC is considered as the preferred analytical instrument; nonetheless, considering the information required in order to apply this method, an explicit consensus of the OMB will be required if agencies prefer the SPC to the basic 7\% discounting.

With the Circular A-4\textsuperscript{170} of the 17\textsuperscript{th} of September 2003\textsuperscript{171}, OMB provides more specific guidance to Federal Agencies in order to develop RIAs. In this circular the necessity to discount future benefits and costs is explicitly expressed, pointing out that “it is important to measure them in constant dollars”\textsuperscript{172}, therefore preferring an evaluation in real terms. For the selection of the discount rate, the Circular A-4 refers to the Circular A-94, adding further information. Perplexities are expressed on the application of the SPC method because “shadow prices are not well established for the United States” and “the distribution of impacts from regulations on capital and consumption are not always well known”\textsuperscript{173}. The 7\% discount rate set in the Circular A-94 is considered an approximation of the opportunity cost of capital\textsuperscript{174}, therefore it is appropriate when the assessed regulation displaces private investments. An additional discount rate of 3\% is provided as approximation of the Social Rate of Time Preference

\textsuperscript{167}The previous discount rate, suggested in the Circular A-94 issued on the 27\textsuperscript{th} of March 1972, was equal to 10\%.
\textsuperscript{168}Circular A-94 (29/Oct/1992), p.9. This rate can be considered an estimation of the SMRRPI.
\textsuperscript{169}\textit{Ibidem}, p.9. For instance, the use of a higher discount rate is required to evaluate regulatory proposals whose main cost is to diminish business investments.
\textsuperscript{170}Circular A-4 (17/Sep/2003).
\textsuperscript{171}This circular took effect in January 2004 for proposed rules and January 2005 for final rules.
\textsuperscript{172}Circular A-4 (17/Sep/2003), p.32.
\textsuperscript{173}\textit{Ibidem}, p.33.
\textsuperscript{174}This is the SMRRPI approach (see paragraph 3.3.2.2. supra).
(SRTP)\textsuperscript{175} by computing the real rate of return on long-term government debt. Considering that a regulatory project can crowd out both private investments and private consumptions, regulatory analysis should provide the NPV under both rates (3\% and 7\%). A further sensitivity analysis at a rate higher than 7\% (for instance, 10\%) is recommended if the policy displaces investments in the corporate sector.

The necessity of discounting also health-related benefits and costs is emphasized, judging as inappropriate any criticism on the topic. Also the problem of the intergenerational discounting is tackled, suggesting two alternative approaches: using the standard discount techniques, but delivering to policy-makers an additional analysis where the intergenerational concerns are discussed; carrying out a further sensitivity analysis with a discount rate lower than 3\%, but still positive\textsuperscript{176}.

The numerical values and the sensitivity analysis approach suggested in the Circular A-4 of 2003 are confirmed in the “Regulatory Impact Analysis: Frequently Asked Questions”\textsuperscript{177} published by the OMB in 2011.

\textbf{4.1.1.2. The Environmental Protection Agency}

The EPA issued the new “Guidelines for Preparing Economic Analyses”\textsuperscript{178} in December 2010, revising a similar document issued in 2000\textsuperscript{179} in order to foster the “use of sound science in support of the decision-making process”, therefore including the most

\textsuperscript{175} This is the SMRTP approach (see paragraph 3.3.2.3., supra).

\textsuperscript{176} Using the same positive discount rate across generations is explicitly considered attractive from an ethical standpoint.

\textsuperscript{177} Circular A-4 FAQs (7/Feb/2011).

\textsuperscript{178} EPA (2010).

\textsuperscript{179} In the guidelines of 2000 (EPA (2000)): for the intragenerational discounting, the EPA recommended to use both a discount rate from 2\% to 3\% and the 7\% suggested by OMB, adding a display of the future streams of benefits and costs without computing the NPV, and other sensitivity analyses with a discount rate between 2\% and 7\%; for intergenerational discounting, an additional sensitivity analysis with a discount rate between 1,5\% and 3\% was required. In the previous reference document of the EPA (1983) a two-stage procedure was suggested: in the first stage, the cost of capital had to be annualized over the lifetime of the project using the SMRRI (10\%); in the second stage, the streams of benefits and costs had to be discounted using the SMRTP (3\%).
recent “development of economic tools and practices.” Section 6 of this official document deals with discounting future benefits and costs.

The agency underlines the difference between discounting and accounting for inflation, pointing out that analysts should consider real values and real discount rates. Likewise, risk should never be included in the discounting analysis, since future benefits and costs should be already monetized as expected. Furthermore, the difference between social discounting and private discounting is stressed, explaining that the agency should consider discounting from the perspective of the whole society.

Theoretical descriptions of the SRTP, the social opportunity cost of capital, and the SPC approaches are provided. Despite the SPC method is deemed “the preferred analytic approach”, it is considered too “difficult to implement in practice.” Considering that the EPA policies usually cost a very small fraction of the whole yearly U.S. government borrowings, EPA programs are assumed to not displace private investments. It follows that environmental regulations should be discounted just considering the SRTP. Furthermore, a box is dedicated also to other social discounting perspectives, including the main results of behavioral and experimental economics and explaining that this literature is not enough well established to be applied in a CBA of regulatory policies.

A broad analysis focuses on the issue of the intergenerational social discounting. The agency shows the awareness that the "conventional" discounting techniques could be

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181 It is the SMRTPI (see paragraph 3.3.2.3., supra). EPA suggests to estimate this rate with the long-term after-tax and after-inflation returns on savings instrument. An alternative estimation could be provided using the Ramsey (1928) framework (see paragraph 3.3.4, supra). The value of this rate should be included between 2% and 4%.
182 It is the SMRRP (see paragraph 3.3.2.2, supra). EPA suggests to estimate this rate with the pre-tax marginal rate of return on private investment. The value of this rate should be included between 4.5% and 7%.
183 EPA (2010), p.6-10, 6-11.
inappropriate for CBAs of projects characterized by very long time horizons. In order to
discount intergenerational effects, different theoretical alternatives are suggested,
such as the application of a constant discount rate without differences among
intragenerational and intergenerational discounting;\textsuperscript{184} the use of a step function
which leads to a time-declining discount rate\textsuperscript{185} and, more in general, the use of non-
constant discount rate; the use of a constant discount rate, but adjusted for
uncertainty\textsuperscript{186}.

Eventually, EPA points out that economists are far from a consensus on the selection
of the most appropriate discount rate for CBA of public projects. Therefore the agency
provides recommendations which “are intended as practical and plausible default
assumptions rather than comprehensive and precise estimates of social discount
rates.”\textsuperscript{187} The opportunity to use more accurate empirical estimates is left to analysts,
together with the duty to explain the rationale of their decisions. EPA recommends to:

- display the timing of benefits and costs over the time horizon of the
  assessed program;
- compute the NPV using the 3\% value;
- compute the NPV using also the 7\% rate;
- take into account the problem of the intergenerational discounting for a
time horizon higher than 50 years where NBs significantly vary over time,
  thus adding to the previous analyses a further sensitivity analysis using
  alternatively a time-declining rate or a lower constant discount rate.

\textsuperscript{184} This approach totally ignores economic growth.
\textsuperscript{185} In this approach the selection of the time horizon from which the discount rate should decline is left to analysts.
\textsuperscript{186} This approach leads to the use of a lower discount rate; uncertainty does not refer to future benefits and costs
included in the analysis, it refers to economic growth and expected discount rates.
\textsuperscript{187} EPA (2010), p. 6-22.
Any alternative methods used by analysts “should be fully described, supported, and justified”\textsuperscript{188}. No room is left to use different discount rates for benefits and costs and, among benefits, for impacts on human life, environmental conditions and so on.

4.1.1.3. The Nuclear Regulatory Commission

The NRC published the “Regulatory Analysis Guidelines” revised in August 2004 in order to guide “regulatory analyses to support numerous regulatory actions that affect the agency’s reactor and materials licensees” \textsuperscript{189}. All costs and benefits, including the impacts on public health and safety, have to be monetized and expressed on a present-worth basis. The NPV, in accordance with the OMB guidelines, has to be computed considering both a 3% and a 7% real discount rate, with the possibility to use other rates for further sensitivity analyses only if sufficiently justified.

The NRC addresses also the problem of the intergenerational discounting. As a result, analysts should explicitly discuss the impact of the regulation on future generations. From this perspective they should provide additional information, such as future costs and benefits considering the moment they occur without computing the NPV. A supplemental sensitivity analysis with a lower, but positive, discount rate is also allowed in these circumstances.

4.1.1.4. The Government Accountability Office and The Congressional Budget Office

The “Discount Rate Policy”\textsuperscript{190} of the GAO is expressed in an official document issued in May 1991, which provides an in-depth analysis of the discounting issue. “In general,

\textsuperscript{188} EPA (2010), p.6-23.
\textsuperscript{189} NRC (2004), p.VII.
\textsuperscript{190} GAO (1991).
the discount rate for GAO analyses should be the interest rate on marketable Treasury
debt with maturity comparable to that of the program being evaluated\textsuperscript{191}, underlining
that economists have not reached a consensus on alternative techniques, neither
empirically nor theoretically. This rate is deemed appropriate for future benefits and
costs estimated in nominal terms, otherwise it is necessary to adjust it to reflect the
expected inflation. This approach, which can be considered as an application of the
government borrowing rate method (see paragraph 3.2.2.4., supra), is considered as a
practical way to appraise the government opportunity cost.

Furthermore, the GAO recommends a strong application of the sensitivity analysis
taking into account: alternative inflation rates or interest rates whenever significant
differences exist among various reliable economic forecasts; private sector discount
rates, in case of evaluation of asset divestitures; estimates of the private sector
opportunity cost and of the rate of time preference, whenever regulatory policies or
public projects are assessed; the necessity to apply a very low discount rate in case the
analysis involves intergenerational human life effects; an adjustment for the risk of the
assessed project; any consideration about the appropriate discount rate suggested by
other agencies.

In the discount rate policy document of the GAO\textsuperscript{192}, it is possible to find also
information about the CBO discounting policy. For most analyses, the CBO suggests a
discount rate based on the real yield of Treasury debt. More precisely, in 1990 the

\textsuperscript{191} GAO (1991), chapter 1. This methods of estimation of the SDR replaces the previous GAO policy, expressed in
chapter 17 of the "Project Manual" (GAO (1983)), where "the average nominal yield of marketable Treasury debt
with remaining maturities between one year and the length of the project being evaluated" was recommended.

\textsuperscript{192} GAO (1991).
discount rate is estimated to be 2%\textsuperscript{193}. Moreover, the CBO recommends a sensitivity analysis both with a higher (+2%) and a lower (-2%) rate, thus capturing the potential variability of real yields. Nevertheless, in the “CBO’s 2011 Long-Term Budget Outlook”, the CBO takes into account three different interest rates as benchmarks, including “the interest rate on 10-year Treasury notes, the average interest rate on government debt, and the interest rate on holdings of the Social Security and Medicare trust funds”\textsuperscript{194}. The projection for the real interest rate on 10-year Treasury notes is 3%. The average real interest rate on government debt is set at 2.7%. Therefore, the CBO applies a discount rate of 2.7% to calculate “the present value of future streams of total federal revenues and outlays”\textsuperscript{195}. To the contrary, considering that “the Social Security and Medicare trust funds hold longer-term debt”, to compute “the present value of future streams of revenues and outlays for the trust funds, CBO [uses] 3% as the discount rate”\textsuperscript{196}.

4.1.2. European Union

In this section the EU IA world is examined. The analysis is focused on the “Impact Assessment Guidelines”\textsuperscript{197} issued by the EC. A quick look is given also to the “Guide to Cost Benefit Analysis of Investment Project”\textsuperscript{198} also published by the EC.

4.1.2.1. The European Commission

On the 15\textsuperscript{th} of January of 2009 the EC published the new “Impact Assessment Guidelines”\textsuperscript{199} which replaced the previous guidelines issued in 2005 and updated in

\textsuperscript{193} This rate is considered a SMRTP in order to carry out social welfare analysis (Hartman (1990)).
\textsuperscript{194} CBO (2011), p.23.
\textsuperscript{195} Idem, p.24.
\textsuperscript{196} Idem, p.24. This is the rate used in the section of the CBO’s outlook (CBO (2011)) dedicate to the spending on health care.
\textsuperscript{197} EC (2009).
\textsuperscript{198} EC (2008).
2006. Among the main steps to carry out a CBA, the Commission explicitly states that
the value of the impacts has to be monetized, discounting at a standard discount rate
impacts occurring in the future.

The discounting issue is directly tackled in the Annex 11.6 of the guidelines\(^{200}\). The
selected discount rate is of 4%, and “broadly corresponds to the average real yield on
longer-term government debt in the EU over a period since the early 1980s”\(^{201}\),
therefore it is expressed in real terms and should be applied to future benefits and
costs estimated at constant prices. For long-term policies a discount rate lower than
4% might be used, in order to deal with “the longer term implications of sustainable
development and in particular, the need to take proper account of the preferences of
future generations”\(^{202}\). Nevertheless, in the note 65 the Commission states that “for
impacts occurring more than 30 years in the future, the use of a declining discount rate
could be used for sensitivity analysis, if this can be justified in the particular
context”\(^{203}\).

It is worthwhile to point out that the EC itself in the “Guide to Cost Benefit Analysis of
Investment Projects”\(^{204}\), applying a Ramsey approach (see paragraph 3.3.4., supra),
suggests a reference SDR for the period 2007-2013 of 3.5% for countries not eligible
for the cohesion fund and of 5.5% for cohesion fund countries, also explaining that
France in 2005 had already fixed a SDR of 4% (formerly 8%), Germany in 2004 of 3%
(formerly 4%) and UK in 2003 of 3.5% (formerly 6%).

\(^{199}\) EC(2009a).
\(^{200}\) EC (2009b); the Annex 11.6 is the exact copy of the Annex 12 of the previous guidelines (EC 2006).
\(^{201}\) EC (2009b), p.71. This rate, according to the suggestions of Nas (1996) and Boardman et al. (2006), can be
considered a SMRTP (see paragraph 3.3.2.3., supra).
\(^{202}\) Ibidem, p.71.
\(^{203}\) Ibidem, p.71.
\(^{204}\) EC (2008).
4.1.3. Summing-up

A summary of the main findings provided by the examination of the recommendations of USA and EU public authorities is included in Appendix A (infra). In US official documents, the academic discussion on the discounting issue is explicitly taken into account, acknowledging the SPC as the preferred analytical solution. Nevertheless, regulators need practical solutions to be adopted in CBA. Therefore, the discount rates are just estimated as SMRT (3%) and SMRRP (7%), considering the possibility to displace both national consumptions and private investments. In all the circumstances, all kind of benefits and costs must be discounted at the same rate and considerations about risk and uncertainty should not be included in the SDR. Moreover, the sensitivity analysis is highly recommended and several feasible solutions are also suggested to tackle the intergenerational discounting issue. To the contrary, the EU guidelines are definitely less accurate, only a SMRT (4%) is recommended and the sensitivity analysis is suggested just as a solution to the intergenerational discounting problem.

4.2. The discount rate used by analysts: evidences from a sample of cost-benefit analyses

In the paragraph 4.2. an analysis centered on the practical use of the SDR in CBA of legislative and regulatory policies is provided. The attention focuses on the RIAs carried out by the US EPA and on the IAs of the EU Directorate-General for the Environment (DG ENV) during the period 2005-2010.

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205 Environmental agencies have been selected because it is more likely that their policies involve long-term effects and intergenerational issues.
206 This period has been selected because the Circular A-4 of the OMB took effect in January 2005 and that the first EC guidelines, which provided the same information of the current guidelines of 2009, took effect in June 2005.
4.2.1. The regulatory impact analyses of the US Environmental Protection Agency between 2005 and 2010

Since 1997, the OIRA has been issuing a yearly “Report to Congress on the Benefits and Costs of Federal Regulations”\(^{207}\) where it is possible to find a list of all the major rules\(^{208}\) reviewed by the OMB from the 1\(^{st}\) of October of two years before the publication of the report to the 30\(^{th}\) of September of the year before. Therefore, consulting the reports issued from 2006 to 2011\(^{209}\), it is possible to identify all the final rules for which a RIA of the EPA has been reviewed by the OMB between 2005 and 2010. RIAs of the selected final rules can be found online alternatively on the web-site of the EPA or in the docket of any rule stored on the web-site http://www.regulations.gov\(^{210}\). A complete list of the RIAs analyzed is provided in the Appendix B (infra) of this work\(^{211}\). The Table 4.1. (infra) shows a summary of the main results.

From the 1\(^{st}\) of October 2004 to the 30\(^{th}\) of September 2010 (6 years period), EPA carried out 24 RIAs for final rules reviewed by the OMB. 23 RIAs out of 24 are available

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\(^{208}\) The definition of “major rule” which requires the congressional review is provided in Subtitle E of the Small Business Regulatory Enforcement Fairness Act of 1996: “(A) an annual effect on the economy of $100,000,000 or more; (B) a major increase in costs or prices for consumers, individual industries, Federal, State, or local government agencies, or geographic regions; or (C) significant adverse effects on competition, employment, investment, productivity, innovation, or on the ability of United States-based enterprises to compete with foreign-based enterprises in domestic and export markets”. (See http://archive.sba.gov/advo/laws/sbrefa.html visited on 9/Aug/2011).


\(^{210}\) Regulations.gov is the official online source for US government regulations from 300 Federal agencies, thus improving the access of the US citizens to and the participation in the Federal regulatory process (web-site visited on July 2011).

\(^{211}\) The table includes the following information: OMB review period; RIA date; rule name and reference; calculation of NBs; use of the discount rate; compliance with EPA guidelines; ad hoc estimation of the discount rate; discount rate used; sensitivity analysis on discount rate; real/nominal discount rate; time horizon; intergenerational discounting.
online and are included in this empirical analysis. 19 RIAs (83% of the total available RIAs) can be defined as CBAs because they include a computation of NBs\textsuperscript{212}.

Table 4.1. The discount rate in US EPA RIAs, period 2005-2010

<table>
<thead>
<tr>
<th>EPA RIAs for FINAL RULES reviewed by OMB (available RIAs in brackets)</th>
<th>EPA RIAs with calculation of net benefits (CBA)</th>
<th>EPA RIAs with use of discount rate (CBA)</th>
<th>EPA RIAs with specification of real or nominal discounting (CBA)</th>
<th>EPA RIAs with 3% and 7% discounting (even just for benefits or costs) (CBA)</th>
<th>EPA RIAs with independent estimation of discount rate (CBA)</th>
<th>EPA RIAs with sensitivity analysis on discounting (CBA)</th>
<th>EPA RIAs which tackle the inter-generational discounting problem</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of RIAs</td>
<td>24 (23)</td>
<td>19</td>
<td>22</td>
<td>21</td>
<td>1</td>
<td>21</td>
<td>2</td>
</tr>
<tr>
<td>of which with calculation of net benefits (CBAs)</td>
<td>19</td>
<td>19</td>
<td>18</td>
<td>18</td>
<td>1</td>
<td>18</td>
<td>1</td>
</tr>
<tr>
<td>Percentage on Total Available RIAs (23)</td>
<td>-</td>
<td>83%</td>
<td>96%</td>
<td>96%</td>
<td>91%</td>
<td>4%</td>
<td>91%</td>
</tr>
<tr>
<td>Percentage on RIAs with calculation of net benefits (CBAs)</td>
<td>-</td>
<td>-</td>
<td>95%</td>
<td>95%</td>
<td>95%</td>
<td>5%</td>
<td>95%</td>
</tr>
</tbody>
</table>

In the 95% (18) of the total CBAs carried out by EPA a discounting technique is applied, always using the real discount rates recommended in the EPA guidelines and developing a sensitivity analysis (at least either for benefits or for costs). Only in 1 case an \textit{ad hoc} estimation of the most appropriate SDR is provided. Likewise, the intergenerational issue is tackled only in 1 CBA out of 19. From an in-depth examination of the EPA RIAs, the following additional findings emerge: the sensitivity analyses are usually carried out using the 3% and 7% rates, only in few cases a 0%

\textsuperscript{212} In order to have an objective selection criterion, the computation of NBs is assumed to be a proxy of the application of CBA method. Actually EPA RIAs are not so well-structured as a comprehensive CBA should be.
discounting analysis is added, and in no case a rate higher than 7% is applied; the sensitivity analyses are sometimes partial, applied either to costs or to benefits with distorting effects on the NBs; the time horizons chosen by analysts usually are very short, thus avoiding, without robust justifications, the intergenerational discounting problem.

4.2.2. The regulatory impact assessments of the EU Directorate-General for the Environment between 2005 and 2010

A list of all the IAs carried out by the EC are available online on the web-site http://ec.europa.eu/governance/impact/ia_carried_out/cia_2011_en.htm\textsuperscript{213}. From that list all the IAs made by DG ENV between 2005 and 2010 are selected and included in the current analysis. A complete list of the IAs analyzed is provided in the Appendix C (\textit{infra}) of this work\textsuperscript{214}. The Table 4.2. (\textit{infra}) shows a summary of the main results.

From the 1\textsuperscript{st} of January 2005 to the 31\textsuperscript{st} of December 2010 (6 years period), DG ENV carried out 51 IAs for proposal adopted by the EC. Only 9 IAs (18% of the total IAs) can be defined as CBAs because they include a computation of NBs\textsuperscript{215}. In the 89% (8) of the total CBAs carried out by DG ENV a discounting technique is applied, always using the discount rate recommended in the EC guidelines (even if only in 1 case analysts point out that the analysis is carried out in real terms).

\textsuperscript{213} This web-site is the official source of EC IA reports which are published online after the EC has adopted the corresponding proposal.

\textsuperscript{214} The table includes the following information: adoption date; rule name and reference; legal effect of the rule; calculation of NBs; use of the discount rate; compliance with EU guidelines; ad hoc estimation of the discount rate; discount rate used; sensitivity analysis on discount rate; real/nominal discount rate; time horizon; intergenerational discounting. The table has been developed verifying, integrating and upgrading a database of the Centre for European Policy Studies.

\textsuperscript{215} In order to have an objective selection criterion, the computation of NBs is assumed to be a proxy of the application of CBA method. This proxy in EU is weaker than in US because NBs in DG ENV IA are not so often the result of a genuine CBA.
Table 4.2. The discount rate in EU DG ENV IAs, period 2005-2010

<table>
<thead>
<tr>
<th></th>
<th>DG ENV IAs for adopted proposal</th>
<th>DG ENV IAs with calculation of net benefits (CBAs)</th>
<th>DG ENV IAs with use of discount rate</th>
<th>DG ENV IAs with specification of real or nominal discounting</th>
<th>DG ENV IAs with 4% discounting (even just for benefits or costs)</th>
<th>DG ENV IAs with independent estimation of discount rate</th>
<th>DG ENV IAs with sensitivity analysis on discounting</th>
<th>DG ENV IAs which tackle the inter-generational discounting problem</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of IAs</td>
<td>51</td>
<td>9</td>
<td>13</td>
<td>11</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>of which with calculation of net benefits (CBAs)</td>
<td>9</td>
<td>9</td>
<td>8</td>
<td>1</td>
<td>8</td>
<td>0</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Percentage on total IAs</td>
<td>-</td>
<td>18%</td>
<td>25%</td>
<td>2%</td>
<td>22%</td>
<td>0%</td>
<td>6%</td>
<td>0%</td>
</tr>
<tr>
<td>Percentage on IAs with calculation of net benefits (CBAs)</td>
<td>-</td>
<td>-</td>
<td>89%</td>
<td>11%</td>
<td>89%</td>
<td>0%</td>
<td>22%</td>
<td>0%</td>
</tr>
</tbody>
</table>

A sensitivity analysis (at least either for benefits or for costs) is developed only in 2 CBAs (the 22% of the CBAs). In no case the estimation of an *ad hoc* discount rate is provided, neither the intergenerational discount issue is tackled. From an in-depth examination of the DG ENV IAs, the following additional findings emerge: IAs and CBAs are carried out both for binding and non binding proposals; the sensitivity analyses are often partial, applied either to costs or to benefits with distorting effects on the computed NBS; likewise, in several cases either costs or benefits are not discounted, while in few cases relatively high discount rate (8%, 10% or 12%) are adopted; finally, also in Europe, the time horizons chosen by analysts usually are very short, thus avoiding, without robust justifications, the intergenerational discounting problem.
4.2.3. Summing-up

From the analysis of the selected sample of US RIAs and EU IAs a broad difference between the American and the European approach arises. In the USA, the use of the CBA to compute the NBs of a regulatory policy is widespread as well as the application of discounting techniques according to the recommendations of the regulators. In almost all cases a sensitivity analysis of the discount rate is provided, thus evaluating the robustness of the CBA and offering a workable solution to the absence of an theoretical consensus on the most appropriate SDR to be adopted. The intergenerational discount issue is not really tackled by analysts that prefer to bypass it fixing a relatively short time horizon for the analyses. To the contrary, in the EU the adoption of the CBA method for the IAs is very limited and even in the cases where NBs are computed, analysts do not undertake a genuine CBA. The application of discounting techniques is even more limited and in many cases it is partial, involving either only costs or benefits or just few of the evaluated alternatives with distorting effect on IA results. Sensitivity analyses on discounting have a marginal role and, also in EU, the intergenerational problem is just bypassed by analysts.

It is very important to underline that, both in USA and in EU, analysts never explicitly face the problem of the selection of the most appropriate SDR for the CBA that they are carrying out. Any discussion on the discount rate is left to the regulators’ recommendations. In case the CBA (and more generally RIA or IA) includes a discounting analysis, analysts either, in the best case, confine themselves to adopt the suggestions included in official documents or guidelines (usually in USA) or, in the
worst one, use a given discount rate without a plausible explanation (usually in the EU).
Chapter 5. Conclusions

5.1. The discount rate between theory and practice

By surveying the main academic discussions on discounting issue, it is possible to agree with the conclusion of Robert J. Brent who argues that “the literature on the social discount rate is anything but clear”\textsuperscript{216}. The methods of estimation of the SDR which are more reliable and theoretically unobjectionable, such as the SPC approach, result unworkable because of the huge difficulties in appraising the variables involved in the analysis. To the contrary, the solutions which are more feasible, such as the SMRRPI or the SMRTP, result appropriate just in particular situations and are open to several criticisms. As a result, an agreement on the most appropriate SDR to be used in any circumstance has not been reached yet. Furthermore, the current debate on the intergenerational discounting issue is even casting new doubts on the desirability of discounting future benefits and costs. Therefore, a widespread consensus seems to exist only on the adoption of a sensitivity analysis to evaluate the effects that different discount rates have on the results of a CBA.

It is not by chance that a considerable agreement has been reached only on the application of the sensitivity analysis method, which is a pragmatic solution to the uncertainty related to the selection of the SDR. This observation could demonstrate that a connection between theory and practice can be established only when “theoreticians” are able to deliver workable instruments to “practitioners”. Two other evidences support this argument. First of all, analysts never face directly the

discounting issue when they carry out CBAs of public policies; they actually bypass the problem relying on official guidelines. Secondly, despite regulators take into account the academic debate, they point out the inapplicability of the more elegant analytical solutions and they end up in suggesting one or two SDRs to be applied in all the circumstances, highly recommending a sensitivity analysis to minimize doubts on the CBA results.

Regulators certainly act as a bridge between theory and practice. As a result, if scholars really aim at improving the reliability of the CBA to assess public policies, it goes without saying that they should address their work to regulators and that the North star of any research should be the easiness of applicability of the expected results. From the research perspective, it is worthwhile to underline that the literature on SDR is centered on the assessment of public projects, thus completely lacking an academic debate explicitly focused on discounting legislative and regulatory options. By considering that these policies frequently do not involve direct public spending and that they just impose costs and benefits on the society, new research on SDR could try to investigate this specific feature.

5.2. Concluding remarks on the role of the cost-benefit analysis

A “normative” role for CBA in the assessment of legislative and regulatory policies is hard to imagine. The controversial methodological problems which still exist from a theoretical perspective are even amplified in the practical analysis where standard and workable solutions are preferred to analytically rigorous application of the main academic findings. Furthermore, despite of the institutionalization of CBA in the regulatory process, the adoption of a comprehensive CBA scheme is still limited.
Between 2005 and 2010 the 83% of the RIAs carried out by the US EPA and only the 18% of the IAs of the EU DG ENV included the computation of the NBs. To be fair, in USA, as Jacobs \(^{217}\) explain, it is just possible to speak about “soft” CBA in which quantitative and qualitative evaluations are mixed, without monetizing all the benefits and the costs of a policy. In EU the situation is even worse and the computation of NBs does not so often rely on a genuine CBA.

From another perspective, the “supportive” role of CBA, as a powerful tool for organizing information and reducing the large complexity of the policy-making process, has an indisputable value. Therefore efforts must be made to simplify the application of the CBA method and to foster its real adoption in the regulatory process. As Arrow et al.\(^{218}\) argue: “[b]enefit-cost analysis can play an important role in legislative and regulatory policy debates on protecting and improving health, safety, and the natural environment. Although formal benefit-cost analysis should not be viewed as either necessary or sufficient for designing sensible public policy, it can provide an exceptionally useful framework for consistently organizing disparate information, and in this way, it can greatly improve the process and, hence, the outcome of policy analysis”.

\(^{217}\) Jacobs (2007).
\(^{218}\) Arrow et al. (1996), p.222.
6. Bibliography


EC (2009b), *Part III: Annexes to Impact Assessment Guidelines*, 15 January 2009, European Commission, available online at the following link:


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GAO (1991), Discount Rate Policy, United States General Accounting Office, Office of the Chief Economist, Washington, D.C.


## Appendix A. The recommendations on the discount rate of US and EU public authorities

<table>
<thead>
<tr>
<th>Public authority</th>
<th>SDR</th>
<th>SDR method</th>
<th>SDR theoretical notes</th>
<th>Sensitivity analysis on discount rate</th>
<th>Inter-generational discounting</th>
</tr>
</thead>
<tbody>
<tr>
<td>US OMB C-94</td>
<td>7% (real)</td>
<td>SMRRPI</td>
<td>SPC is the preferred analytical instrument, to be adopted only under OMB explicit consensus</td>
<td>Higher rate if business investments are displaced</td>
<td>NO</td>
</tr>
<tr>
<td>US OMB C-4</td>
<td>3% (real)</td>
<td>SMRRPI (7%)</td>
<td>SMRTPI (3%)</td>
<td>SPC should not be used because of lack of reliable data</td>
<td>3% and 7%; higher rate – 10% - if investments in the corporate sector are displaced; lower for inter-generational discounting.</td>
</tr>
<tr>
<td>US EPA guidelines</td>
<td>3% (real)</td>
<td>SMRRPI (7%)</td>
<td>SMRTPI (3%)</td>
<td>SPC is the preferred analytical instrument, but inapplicable; SMRTPI is the appropriate SDR for EPA project (assuming no displacement of private investments); Lack of consensus among economists</td>
<td>3% and 7%; lower rate or time-declining rate for inter-generational discounting.</td>
</tr>
<tr>
<td>US NRC guidelines</td>
<td>3% (real)</td>
<td>NO INFO</td>
<td>NO INFO</td>
<td>Only if sufficiently justified.</td>
<td>Standard discounting with explicit discussion on the issue; or sensitivity analysis at a lower discount rate.</td>
</tr>
<tr>
<td>US GAO discount rate policy</td>
<td>Interest rate on marketable Treasury debt with maturity comparable to that of the program being evaluated (nominal rate).</td>
<td>Government borrowing rate</td>
<td>Lack of consensus among economists</td>
<td>Strong application in several circumstances.</td>
<td>Sensitivity analysis.</td>
</tr>
<tr>
<td>---------------------------</td>
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<td>----------------------</td>
</tr>
<tr>
<td>US CBO (Long-Term Budget Outlook)</td>
<td>Real interest rate on 10-year Treasury notes (3%); average real interest rate on government debt (2.7%).</td>
<td>SMRT (Hartman 1990)</td>
<td>NO INFO</td>
<td>NO (According to GAO official document, CBO recommends a sensitivity analysis both with a higher (+2%) and a lower (-2%) rate).</td>
<td>NO</td>
</tr>
<tr>
<td>EU EC Guidelines</td>
<td>4% (real)</td>
<td>SMRT</td>
<td>NO INFO</td>
<td>Recommended in case of inter-generational discounting</td>
<td>Sensitivity analysis at a lower discount rate; declining discount rate for impacts beyond 30 years if explicitly justified.</td>
</tr>
</tbody>
</table>
# Appendix B. The discount rate in US EPA RIAs, period 2005-2010

<table>
<thead>
<tr>
<th>OMB review period</th>
<th>RIA date</th>
<th>Rule name and reference</th>
<th>Calculation of net benefits</th>
<th>Use of the discount rate</th>
<th>Compliance with EPA guidelines (3% and 7%)</th>
<th>Ad hoc estimation of the discount rate</th>
<th>Discount rate used</th>
<th>Sensitivity analysis on discount rate</th>
<th>Real/nominal discount rate</th>
<th>Time horizon</th>
<th>Intergenerational discounting</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Oct 2004/30 Sep 2005</td>
<td>2005 March</td>
<td>Clean Air Mercury Rule--Electric Utility Steam Generating Units [70 FR 28606]</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
<td>3% and 7%</td>
<td>YES</td>
<td>real (1999 $)</td>
<td>2005-2020 + max 50 years lag period</td>
<td>1% for 50 years lag period</td>
</tr>
<tr>
<td>OMB review period</td>
<td>RIA date</td>
<td>Rule name and reference</td>
<td>Calculation of net benefits</td>
<td>Use of the discount rate</td>
<td>Compliance with EPA guidelines (3% and 7%)</td>
<td>Ad hoc estimation of the discount rate</td>
<td>Discount rate used</td>
<td>Sensitivity analysis on discount rate</td>
<td>Real/nominal discount rate</td>
<td>Time horizon</td>
<td>Inter-generational discounting</td>
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</tr>
<tr>
<td>1 Oct 2005/30 Sep 2006</td>
<td>2006 June</td>
<td>Review of the National Ambient Air Quality Standards (NAAQS) for Particulate Matter [71 FR 61144]</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
<td>3% and 7%</td>
<td>YES</td>
<td>real (1999 $)</td>
<td>2006-2020 + lag period</td>
<td>NO</td>
</tr>
<tr>
<td>OMB review period</td>
<td>RIA date</td>
<td>Rule name and reference</td>
<td>Calculation of net benefits</td>
<td>Use of the discount rate</td>
<td>Compliance with EPA guidelines (3% and 7%)</td>
<td>Ad hoc estimation of the discount rate</td>
<td>Discount rate used</td>
<td>Sensitivity analysis on discount rate</td>
<td>Real/nominal discount rate</td>
<td>Time horizon</td>
<td>Inter-generational discounting</td>
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<tr>
<td>1 Oct 2006/30 Sep 2007</td>
<td>N.A.</td>
<td>Clean Air Fine Particle Implementation] [72 FR 20586]</td>
<td>N.A.</td>
<td>N.A.</td>
<td>N.A.</td>
<td>N.A.</td>
<td>N.A.</td>
<td>N.A.</td>
<td>N.A.</td>
<td>N.A.</td>
<td>N.A</td>
</tr>
<tr>
<td>1 Oct 2006/30 Sep 2007</td>
<td>2007 September</td>
<td>Oil Pollution Prevention; Spill Prevention, Control, and Countermeasure (SPCC) Requirements—Amendments [71 FR 77266]</td>
<td>NO</td>
<td>YES</td>
<td>PARTIAL</td>
<td>NO</td>
<td>0%, 3%, and 7%</td>
<td>YES</td>
<td>real (2006 $)</td>
<td>10 years</td>
<td>NO</td>
</tr>
<tr>
<td>OMB review period</td>
<td>RIA date</td>
<td>Rule name and reference</td>
<td>Calculation of net benefits</td>
<td>Use of the discount rate</td>
<td>Compliance with EPA guidelines (3% and 7%)</td>
<td>Ad hoc estimation of the discount rate</td>
<td>Discount rate used</td>
<td>Sensitivity analysis on discount rate</td>
<td>Real/nominal discount rate</td>
<td>Time horizon</td>
<td>Inter-generational discounting</td>
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</tr>
<tr>
<td>1 Oct 2007/30 Sep 2008</td>
<td>2008 September</td>
<td>Control of Emissions from Nonroad Spark-Ignition Engines and Equipment [73 FR 59034]</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
<td>3% and 7%</td>
<td>YES</td>
<td>real (2005 $)</td>
<td>30 years</td>
<td>NO</td>
</tr>
<tr>
<td>OMB review period</td>
<td>RIA date</td>
<td>Rule name and reference</td>
<td>Calculation of net benefits</td>
<td>Use of the discount rate</td>
<td>Compliance with EPA guidelines (3% and 7%)</td>
<td>Ad hoc estimation of the discount rate</td>
<td>Discount rate used</td>
<td>Sensitivity analysis on discount rate</td>
<td>Real/nominal discount rate</td>
<td>Time horizon</td>
<td>Inter-generational discounting</td>
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<tr>
<td>1 Oct 2007/30 Sep 2008</td>
<td>2008 September</td>
<td>Definition of Solid Wastes Revisions [73 FR 64668]</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>No discounting</td>
<td>NO</td>
<td>N.A.</td>
<td>N.C.</td>
<td>NO</td>
</tr>
<tr>
<td>1 Oct 2007/30 Sep 2008</td>
<td>2006 February</td>
<td>Lead-Based Paint; Amendments for Renovation, Repair and Painting [73 FR 21691]</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
<td>3% and 7%</td>
<td>YES</td>
<td>real (2005$)</td>
<td>50 years</td>
<td>NO</td>
</tr>
<tr>
<td>1 Oct 2008/30 Sep 2009</td>
<td>2009 September</td>
<td>Greenhouse Gas Mandatory Reporting Rule [74 FR 56259]</td>
<td>NO</td>
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<td>NO</td>
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<td>2008 October</td>
<td>Review of the National Ambient Air Quality Standards for Lead [73 FR 66963]</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
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Appendix B
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<tr>
<th>OMB review period</th>
<th>RIA date</th>
<th>Rule name and reference</th>
<th>Calculation of net benefits</th>
<th>Use of the discount rate</th>
<th>Compliance with EPA guidelines (3% and 7%)</th>
<th>Ad hoc estimation of the discount rate</th>
<th>Discount rate used</th>
<th>Sensitivity analysis on discount rate</th>
<th>Real/nominal discount rate</th>
<th>Time horizon</th>
<th>Inter-generational discounting</th>
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<td>1 Oct 2009/30 Sep 2010</td>
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<td>Revisions to the Spill Prevention, Control, and Countermeasure (SPCC) Rule [74 FR 58784]</td>
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<td>Control of Emissions From New Marine Compression-Ignition Engines at or Above 30 Liters per Cylinder [75 FR 22897]</td>
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<td>OMB review period</td>
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<td>Rule name and reference</td>
<td>Calculation of net benefits</td>
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<td>Compliance with EPA guidelines (3% and 7%)</td>
<td>Ad hoc estimation of the discount rate</td>
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<td>Review of the National Ambient Air Quality Standards for Sulfur Dioxide [75 FR 35519]</td>
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<td>NO</td>
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<td>real (2006$)</td>
<td>2010-2020</td>
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<td>Renewable Fuels Standard Program [75 FR 14670]</td>
<td>The estimates, although illustrative, do not represent the benefits and costs of the rule</td>
<td>YES</td>
<td>PARTIAL</td>
<td>YES</td>
<td>0% for Lifecycle GHG emission; 3% and 5% for social costs of carbon; 3% and 7% for overall monetized benefits</td>
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### Appendix C. The discount rate in EU DG ENV IAs, period 2005-2010

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<tr>
<th>Adoption date</th>
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<th>Legal effect of the rule</th>
<th>Calculation of net benefits</th>
<th>Use of the discount Rate</th>
<th>Compliance with EU guidelines (4%)</th>
<th>Ad hoc estimation of the discount rate</th>
<th>Discount rate used</th>
<th>Sensitivity analysis on discount rate</th>
<th>Real/nominal discount rate</th>
<th>Time horizon</th>
<th>Intergenerational discounting</th>
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<tr>
<td>09/02/2005</td>
<td>Communication on Winning the Battle against Global Climate Change COM(2005)35</td>
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<td>NO</td>
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<td>28/01/2005</td>
<td>Mercury Strategy COM(2005)20</td>
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<td>NO</td>
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<th>Discount rate used</th>
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<th>Time horizon</th>
<th>Inter-generational discounting</th>
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<td>Flood Management COM(2006)15</td>
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<td>Directive</td>
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<td>Mobilising public and private finance towards global access to climate-friendly, affordable and secure energy services: The Global Energy Efficiency and Renewable Energy Fund COM(2006)583</td>
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<td>Banning of exports and the safe storage of metallic mercury COM(2006)636</td>
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<td>Including aviation activities in the scheme for greenhouse gas emission allowance trading within the Community COM(2006)818</td>
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<td>Report on the targets contained in article 7(2)(b) of Directive 2000/53/EC on end-of-life vehicle COM(2007)5</td>
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Appendix C
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<td>Review of Directive 98/70 relating to fuel quality COM(2007)18</td>
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<td>Regulation setting emission performance standards for new passenger cars as part of the Community's integrated approach to reduce CO2 emissions from light-duty vehicles COM(2007)856</td>
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<th>Legal effect of the rule</th>
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<th>Compliance with EU guidelines (4%)</th>
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<th>Time horizon</th>
<th>Inter-generational discounting</th>
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<td>16/07/2008</td>
<td>Proposal for a regulation on a Community Ecolabel scheme COM(2008)401</td>
<td>Regulation</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
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<td>16/07/2008</td>
<td>Proposal for a Regulation on the voluntary participation by organisations in a Community eco-management and audit scheme (EMAS) COM(2008)402</td>
<td>Regulation</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
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<td>23/07/2008</td>
<td>Proposal for a Regulation concerning trade in seal products COM(2008)469</td>
<td>Regulation</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
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<tr>
<td>01/08/2008</td>
<td>Proposal for a Regulation on substances that delete the ozone layer (Recast) COM(2008)505</td>
<td>Regulation</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
<td>4%</td>
<td>NO</td>
<td>N.A.</td>
<td>2010-2020</td>
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<td>Communication addressing the challenges of deforestation and forest degradation to tackle climate change and biodiversity loss COM(2008)645</td>
<td>Not binding</td>
<td>NO</td>
<td>NO</td>
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<td>17/10/2008</td>
<td>Proposal for a Regulation laying down the obligations of operators who place timber and timber products on the market COM(2008)644</td>
<td>Regulation</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>No discounting</td>
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<td>No discounting</td>
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<td>11/05/2008</td>
<td>Proposal for a Directive on the protection of animals used for scientific purposes COM(2008)543</td>
<td>Directive</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
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<td>18/11/2008</td>
<td>Communication on implementing European Community Environmental Law COM(2008)773</td>
<td>Not binding</td>
<td>NO</td>
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<td>19/11/2008</td>
<td>Communication: 'An EU strategy for better ship dismantling’ COM(2008)767</td>
<td>Not binding</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>No discounting</td>
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<td>03/12/2008</td>
<td>Proposal for a Directive on the restriction of the use of certain hazardous substances in electrical and electronic equipment (recast) COM(2008)809</td>
<td>Directive</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>No discounting</td>
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<td>03/12/2008</td>
<td>Communication: Towards an EU strategy on invasive species COM(2008)789</td>
<td>Not binding</td>
<td>NO</td>
<td>NO</td>
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<tr>
<td>03/12/2008</td>
<td>Proposal for a Directive on waste electrical and electronic equipment (WEEE) COM(2008)810</td>
<td>Directive</td>
<td>YES, only for one of the options, therefore the estimates, although illustrative, do not represent the benefits and costs of the rule</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
<td>N.A.</td>
<td>12 years</td>
<td>NO</td>
<td>No</td>
<td>No discounting</td>
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<td>04/12/2008</td>
<td>Proposal for a Directive on Stage II petrol vapor recovery during refuelling of passenger cars at service stations COM(2008)812</td>
<td>Directive</td>
<td>NO</td>
<td>NO</td>
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<td>23/02/2009</td>
<td>Communication: A Community approach on the prevention of natural and man-made disasters COM(2009)82</td>
<td>Not binding</td>
<td>NO</td>
<td>NO</td>
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<td>No discounting</td>
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<td>01/04/2009</td>
<td>White Paper - Adapting to climate change - Towards a European framework for action COM(2009)147</td>
<td>Not binding</td>
<td>NO</td>
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<td>12/06/2009</td>
<td>Proposal for a Regulation concerning The placing on the market and use of biocidal products COM(2009)267</td>
<td>Regulation</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
<td>4% for costs and cost savings; no monetization of benefits</td>
<td>NO</td>
<td>NO</td>
<td>10 years</td>
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<td>25/06/2009</td>
<td>Communication demonstrating Carbon Capture and Geological Storage (CCS) in emerging developing countries: financing the EU-China Near Zero Emissions Coal Plant project COM(2009)284</td>
<td>Not binding</td>
<td>NO</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
<td>2.5% as public sector borrowing interest rate for subsidies; social discount rate (not specified for other costs); no monetization of benefits</td>
<td>NO</td>
<td>NO</td>
<td>29 years</td>
<td>NO</td>
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<td>28/10/2009</td>
<td>Proposal for a Regulation setting emission performance standards for new light commercial vehicles as part of the Community’s integrated approach to reduce CO2 emissions from light-duty vehicles COM(2009)593</td>
<td>Regulation</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>4% and 10%</td>
<td>YES</td>
<td>real (2000€) only for some estimated costs</td>
<td>various</td>
<td>NO</td>
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<td>24/12/2009</td>
<td>Commission Decision of 24.12.2009 determining, pursuant to Directive 2003/87/EC of the European Parliament and of the Council, a list of sectors and subsectors which are deemed to be exposed to a significant risk of carbon leakage C(2009)10251</td>
<td>Decision</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>No discounting</td>
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<td>21/12/2010</td>
<td>Proposal for a Directive on control of major-accident hazards involving dangerous substances COM(2010)781</td>
<td>Directive</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
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## Appendix D. List of acronyms

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<tr>
<th>Acronym</th>
<th>Meaning</th>
<th>Acronym</th>
<th>Meaning</th>
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<tr>
<td>BIA</td>
<td>Business Impact Assessment</td>
<td>NRC</td>
<td>Nuclear Regulatory Commission (USA)</td>
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<tr>
<td>CBA</td>
<td>Cost-Benefit Analysis</td>
<td>OECD</td>
<td>Organization for Economic Co-operation and Development</td>
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<tr>
<td>CBO</td>
<td>Congressional Budget Office (USA)</td>
<td>OIRA</td>
<td>Office of Information and Regulatory Affairs (USA)</td>
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<td>DG ENV</td>
<td>Directorate-General for the Environment (EU)</td>
<td>OMB</td>
<td>Office of Management and Budget (USA)</td>
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<td>EC</td>
<td>European Commission (EU)</td>
<td>PPC</td>
<td>Production Possibility Curve</td>
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<td>EPA</td>
<td>Environmental Protection Agency (USA)</td>
<td>PV</td>
<td>Present Value</td>
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<td>GAO</td>
<td>Government Accountability Office (USA)</td>
<td>RIA</td>
<td>Regulatory Impact Analysis</td>
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<td>EU</td>
<td>European Union</td>
<td>SDR</td>
<td>Social Discount Rate</td>
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<tr>
<td>IA</td>
<td>Impact Assessment</td>
<td>SIC</td>
<td>Social Indifference Curve</td>
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<td>IAB</td>
<td>Impact Assessment Board</td>
<td>SMRRPI</td>
<td>Social Marginal Rate of Return on Private Investment</td>
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<tr>
<td>IIA</td>
<td>Integrated Impact Assessment</td>
<td>SMRS</td>
<td>Social Marginal Rate of Substitution</td>
</tr>
<tr>
<td>L&amp;E</td>
<td>Law and Economics</td>
<td>SMRT</td>
<td>Social Marginal Rate of Transformation</td>
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<tr>
<td>MIR</td>
<td>Market Interest Rate</td>
<td>SMRTP</td>
<td>Social Marginal Rate of Time Preference</td>
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<tr>
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<td>Marginal Rate of Substitution</td>
<td>SPC</td>
<td>Shadow Price of Capital</td>
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<td>Marginal Rate of Time Preference</td>
<td>SRTP</td>
<td>Social Rate of Time Preference</td>
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<td>NB</td>
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<td>USA (US)</td>
<td>United States of America (United States)</td>
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<tr>
<td>NPV</td>
<td>Net Present Value</td>
<td>WSOCC</td>
<td>Weighted Social Opportunity Cost of Capital</td>
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